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(54) Title: CONFIGURABLE ADAPTIVE GLOBAL TRAFFIC CONTROL AND MANAGEMENT

(57) **Abstract:** A framework for delivery of Internet content includes a subscriber server network; and at least one domain name server constructed and adapted to provide policy-based domain name service, wherein, in response to a request to resolve a hostname, the domain name server resolves the hostname to at least one address corresponding a server in the subscriber server network based on at least one policy consideration. The framework may include a content delivery network, distinct from the subscriber server network, wherein, in response to a request to resolve a hostname, the domain name server provides at least one addresses of a server in the content delivery network based at least on the location of the requestor and other policy considerations. An address returned by the domain name server is selected based on one or more of: (a) geographic policies; (b) load share policies; (c) overflow policies; and (d) network aware policies.

CONFIGURABLE ADAPTIVE GLOBAL TRAFFIC CONTROL AND MANAGEMENT

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1. Field of the Invention

Aspects of the present invention relate to network traffic management. Other aspects of the present invention relate to configurable, adaptive, global traffic control and management in networks such as the Internet.

BACKGROUND & SUMMARY

As the volume of Internet traffic grows, providers of web content and applications increasingly need to deliver content from multiple servers at widely-separated locations in order to sustain a good end-user experience under high traffic loads. This need generates several difficult challenges, including, among others:

- how to guarantee the fault-tolerance of such a multiple-server system in the face of failure of one or more individual servers;
- how to control the way in which requests from end-users are distributed to each server according to important content provider policy constraints imposed for economic, contractual or other reasons; and
- how to guarantee high performance as experienced by end-users as network conditions change.

This invention solves these and other problems by providing a means to distribute network (e.g., Internet) traffic according to a configurable set of rules. The rules can be configured to take into account key factors such as:

- server availability.
- specific requirements of content providers who deploy the invention, e.g., distribution based upon geography, position in IP address space, load share, etc.
- state of the network (Internet) at any given moment, including measures of network latency.

These rules together provide an extremely fine-grained level of network Internet traffic control to providers of Internet content and applications, enabling them to dramatically improve the end-user experience (measured by speed of request resolution, associated download time, and the availability of servers) over that provided by conventional web servers and mirrored server farms.

There are many potential uses for the invention. One use is to provide a stand-alone service directing traffic exclusively to a set of designated servers managed by a single organization. The invention may also be used in more general ways – for example, one or more of the designated destinations can refer to servers (or server collections) outside the organization's control. The latter case includes, for example, Content Delivery Networks (CDN's), as well as local load-balancing servers, as potential destinations. The invention can also be used, e.g., to provide the DNS (Domain Name Service) component of a Content Delivery Network itself. It can be deployed as a service on behalf of subscribers, or it can be deployed as software to be used directly by subscribers themselves.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is further described in terms of exemplary embodiments, which will be described in detail with reference to the drawings. These embodiments are non-limiting exemplary embodiments, in which like reference numerals represent similar parts throughout the several views of the drawings, and wherein:

FIG. 1 depicts a framework according to embodiments of the present invention;

FIG. 2 describes exemplary types of policies, according to embodiments of the present invention;

FIG. 3 shows an exemplary hierarchy or a decision tree built based on subscriber policies, according to embodiments of the present inventions;

FIG. 4 shows an exemplary relationship between a subscriber's network hierarchy and subscriber policies, according to embodiments of the present invention;

FIG. 5 depicts a high level architecture of an adaptive traffic control framework according to embodiments of the present invention;

FIG. 6 depicts a high level functional block diagram of an administrative master agent (AMA) according to embodiments of the present invention;

FIG. 7 depicts the internal functional block diagram of a monitoring mechanism, according to embodiments of the present invention;

FIG. 8(a) is an exemplary flowchart of a process, in which a content delivery framework provides adaptive policy-based domain name service, according to embodiments of the present invention;

FIG. 8(b) is an exemplary flowchart of a process, in which a domain name server resolves a hostname based on policies, according to embodiments of the present invention;

FIG. 8(c) is an exemplary flowchart of a process, in which a monitoring mechanism of a domain name server dynamically monitors the name service operations as well as the availability and the load share status of servers, according to embodiments of the present invention;

FIG. 8(d) is an exemplary flowchart of a process, in which an ATC administrative network maintains dynamic policies and monitors the operations of a content delivery framework, according to embodiments of the present invention;

FIG. 8(e) is an exemplary flowchart of a process, in which an ATC network monitoring mechanism traps events from different domain name servers and generates alerts when necessary, according to embodiments of the present invention;

FIG. 9(a) shows an exemplary secure web based graphical interface, through which a subscriber may define load share and shed fraction policies among static resources, according to embodiments of the present invention;

FIG. 9(b) shows an exemplary interface for defining policies for dynamic servers, according to embodiments of the present invention;

FIG. 9(c) shows an exemplary graphical user interface through which an overflow server may be defined using a canonical name, according to embodiments of the present invention;

FIGS. 10(a) – 10(b) show example subscriber policies, defined based on a set of resource servers, that govern the selection according to geographical location of an incoming request and the time zone of each of the locations, according to embodiments of the present invention;

FIGS. 10(c) – 10(d) show example subscriber policies, defined based on geographical locations of an incoming request with overflow policies that allow the ATC mechanism 150 to direct traffic to pre-defined services when primary servers are not available, according to embodiments of the present invention; and

FIGS. 11(a) – 11(c) show exemplary archived log information that can be displayed and viewed through a graphical user interface, according to embodiments of the present invention.

DETAILED DESCRIPTION

The invention is described below, with reference to detailed illustrative embodiments. It will be apparent that the invention can be embodied in a wide variety of forms, some of which may be quite different from those of the disclosed embodiments. Consequently, the specific structural and functional details disclosed herein are merely representative and do not limit the scope of the invention.

Although there are a number of different scenarios in which the invention might be deployed, this description will focus, for clarity and example only, on a scenario in which DNS service is provided by a third party on behalf of a content or applications provider.

FIG. 1 depicts a high-level of a framework or system **100** according to embodiments of the present invention. A subscriber **102** provides content via a subscriber server network **104** which is made up of one or more server groups **106-1**, . . ., **106-*k*** (collectively **106**).

As used in this description, the framework according to embodiments of this invention contemplates three groups of users:

- An **end-user** who wishes to access content and/or applications over the Internet.
- An **operator** who offers and supports the service on a managed network of computers.
- A **subscriber** (typically a content or applications provider) who subscribes to the operator's service to help to support the needs of the end user.

The terminology end-user, operator and subscriber is used throughout this description to distinguish these three roles, although there are many scenarios in which more than one role can be taken by a single entity. Such scenarios are contemplated by this invention.

Each server group **106** may correspond to a server hierarchy which includes one or more tiers of servers. For example, the first tier of a server hierarchy may comprise one or more primary servers and the second tier of the server hierarchy may comprise possibly one or more overflow servers that are used when the primary servers in the first tier fail to function properly. In general, for the *j-th* server group, the primary servers at the first tier of server group **106-*j*** are denoted **108-*j***, and the overflow servers at the second tier of server group **106-*j*** are denoted **110-*j***.

Each server in a server group is any process or collection of processes that provide resources in response to requests, e.g., from a client. A server can be any off-the-shelf Web server. In some embodiments, servers are typically a Web server such as the Apache server or Netscape Communications Corporation's Enterprise™ server.

Client **112** accesses the subscriber server network **104** in order to obtain content from the subscriber. Content includes any kind of data, including, without limitation, video and audio data and the like. To achieve this access, a user at client **112** enters a resource locator, e.g., a Universal Resource Locator ("URL"), into a browser **114** on client **112**. URLs specify the location of resources (information, data files, etc.) on the network. URLs are defined in detail in T. Berners-Lee et al, Uniform Resource Locators (URL), Network Working Group, Request for Comments: 1738, Category: Standards Track, December 1994, located at "*http://ds.internic.net/rfc/rfc1738.txt*", which is hereby incorporated herein by reference. URLs generally have the following form:

scheme://host[:port]/url-path

where "*scheme*" can be a symbol such as "*file*" (for a file on the local system), "*ftp*" (for a file on an anonymous FTP file server), "*http*" (for a file on a file on a Web server), and "*telnet*" (for a connection to a Telnet-based service). Other schemes can also be used and new schemes are added every now and then. The port number is optional, the system substituting a default port number (depending on the scheme) if none is provided. The "*host*" field (the hostname) maps to one or more particular network addresses for particular computer(s). The "*url-path*" is relative to the computer specified in the "*host*" field. A *url-path* is typically, but not necessarily, the pathname of a file in a web server directory.

The framework or system **100** includes at least one Domain Name Service (DNS) name server **118-1**. In preferred embodiments, the system **100** also includes DNS name servers **118-1, 118-2, . . ., 118-*n***, (collectively referred to as name servers **118**) all operated by a single particular entity. In the embodiment shown in **FIGURE 1**, one of the name servers **118-1** serves the U.S.A., another name server **118-2** serves the U.K., another name server **118-3** serves Japan, and so on. The various name servers **118-1, 118-2, . . ., 118-*n*** can be configured (collectively or individually) to serve geographical regions, geopolitical regions, corporate structures or any other logical organizational structure. The structure and operation of each name server **118** is described below.

When the client's browser **114** obtains a request (e.g., in the form of a URL), the browser queries its resolver **116** for an address for the hostname specified in the requested URL. The resolver **116** eventually queries a particular name server (e.g., name server **118-1**). The name server **118-1** returns (provides or attempts to provide) the IP (Internet Protocol) address (or addresses) of a server (or servers) in the subscriber server network. The determination of the particular IP address returned to the resolver **116** may be based on a number of factors, including the resolver's location (e.g., as determined from the resolver's IP address) and various policies (e.g., subscriber policies **120**, other policies **122**) in a policy database **124**. The client's browser **114** is then able to communicate with the selected server in the subscriber server network in order to obtain the desired resource.

Name servers **118-1, 118-2**, . . ., **118-*n***, according to embodiments of the present invention, include an adaptive traffic control (ATC) mechanism **126** which provides domain name service to a client based on policies in the policy database **124**. Each name server **118** includes or has access to a location determination mechanism **128** for associating the client's request with the client's location. Such a mechanism **128** may be, e.g., the TraceWare™ product of Cable & Wireless PLC. TraceWare™ is suite of services which provide an Internet Atlas which gives real-time, geographic intelligence through its ability to recognize the originating country, region and metropolitan area of Internet consumers.

The subscriber server network **104** represents a network of servers that provides, on behalf of an underlying subscriber, Internet content or services. For example, a subscriber may be a content provider, which has its own network of servers that deliver content to end users' browsers via the Internet. The subscriber server network **104** may be configured in such a way that the processing of the service requests may be reasonably distributed among all the servers in the server network **104**, according to some criteria. To achieve that distribution, the subscriber server network **104** may be organized, for example, to have one or more server groups (e.g., server group 1 **106-1**,..., server group *k* **106-k**), each of which may be responsible for processing a portion of the service requests. For example, service requests coming from Finland may be routed to a server group that is physically located in Europe.

Each server group **106** in the subscriber server network **104** may comprise a plurality of servers to further share the load. For example, a service request from Finland may be subsequently routed to a server located in Scandinavia. Routing service requests to different server groups and subsequently to different servers may be based on various criteria. For example, such routing may be based on the distance between the origin of the request and the location of the server. For example, for a service request originated from Finland, it may be more effective and efficient to direct the request to a server located in Norway instead of directing it to a server located in the U.S. Server load may also be used to determine where to route a service request. For example, a service request originated from the U.S. may be routed to a server group in Mexico if the server group in the U.S. is overloaded while the server group in Mexico is relatively idle.

Servers in a server group may be organized into a hierarchy with one or more tiers of servers. Servers at different tiers may have different designated purposes. For instance, servers at the first tier of a server hierarchy may include servers that are primary functioning servers, servers at the second tier may include servers that are used as overflow servers which become active only when the primary servers at the first tier become unavailable or overloaded, and servers at the third tier that are used as second layer overflow servers that become active only when the primary servers and the overflow (or first layer overflow) servers at the second tier become unavailable or overloaded, etc.

The first tier of a server group hierarchy may include one or more primary servers. When multiple primary servers are present, they may be configured in such a way that they share the load. For example, if there are five primary servers at the first tier, they may be configured so that each takes 20% of the total service requests routed to the server group. For each of such primary servers, it may be further configured so that when a particular server is overloaded or fails, the load share originally designated to this server may be shed or directed to other server(s). The load shed may also be configured when the server is not overloaded. The portion to be shed to other server(s) may be governed by certain pre-defined policies.

As discussed above, servers in a server group **106** may be classified into different categories based on specific functionality of the underlying servers. For example, a server in a server group **106** may be a primary server, a first layer overflow server, or a second layer overflow server, etc. A server may also be classified in terms of whether and how a server is to be dynamically monitored. For instance, in some embodiments, a server can be classified as either a monitored server or a managed server.

A classification of a monitored server indicates that the underlying server is to be monitored dynamically for its availability. In this case, the server may be probed for its availability according to some pre-determined schedule. Such a probe may be sent to the underlying server from different locations of the network so that the availability can be detected accurately. That is, if the underlying server failed to respond to one probe sent from one location, it does not necessarily indicate that the server is no longer available (could be due to that only part of the network is congested).

A probe can be realized in different fashion. It can be simply a signal sent to the server to request an acknowledgement. It can also be a poll operation in which a file stored at a designated location on the underlying server is polled. If the file can be successfully polled, the underlying server is considered to be available. The detected availability may be used to adjust or update policies associated with the server so that the network traffic management will respond to the dynamics related to the server.

A server that is classified as a managed server may be actively participating the adaptive policy-based management scheme. Similar to a monitored server, a managed server may be regularly probed for its availability. In addition, a managed server may dynamically provide information related to its load share or load shed. A managed server may update its load share or load shed fraction according to its changed capacity or its current load. For example, when a managed server is upgraded, its capacity may be increased so that it may increase its load share or decrease its load shed fraction. On the other hand, when a managed server is overloaded, it may revise its load share to a lower level or increase its load shed fraction to prevent failure. A managed server may revise its load share or load shed by updating the corresponding load share or load shed information in a designated file stored on the server and this file may be polled by a name server so that the dynamically changed load share and load shed information can be used to direct traffic accordingly.

The distribution of service requests (from a client **112**) within the subscriber server network **104** may be controlled through a set of ATC policies (**120, 122**) stored in the policy database **124**. Various authorities may influence the ATC policies and may create policies in the policy database **124**. For example, the subscriber may set up policies to direct traffic with respect to considerations such as the geographical locations and the capacities of the underlying servers in the subscriber's network **104**. Other policy entities **138**, including, for example, the operator of the name servers **118** or various geo-political entities may also have policies regarding how the network traffic should be managed and directed. For example, governmental or some organizational agencies may regulate some aspects of network traffic policies. Such regulation policies may be required to be incorporated so that a service request from the client **112** can be routed in a manner that satisfies regulatory policies.

Thus, the ATC policies in the policy database **124** may be a combination of subscriber policies **120** and other policies **122** from different sources such as subscriber **102** and policy entity **138**. Policies from different sources may be accessed by the ATC mechanism **126** from the policy database **124**. From the point of view of the ATC mechanism **126**, the source of a policy may not be relevant or even determinable. For example, policies may be defined in a textual file stored at a designated location, which may be downloaded to an ATC policy management mechanism **152** in an ATC administrative framework **142** and then broadcast to the database manager **132** located in each of the name servers in the ATC name server network **140**. The download may be via either a graphical user interface (GUI), a file transfer protocol (FTP), or some other mechanism. Policy makers may also enter policies directly via a web-based GUI. For example, the subscriber **102** may enter subscriber policies **120** via a browser interface **156** connected with the ATC administrative framework via, preferably a secure interface (e.g., implemented using the "*https*" protocol).

The policies from the policy database **124** used by the ATC mechanism **126** are collectively referred to as ATC policies, which may include, not is not limited to, the subscriber policies **120** as well as other policies **122**. The ATC policies may be organized in a manner that is appropriate to govern and/or control the traffic at different levels of the subscriber server network **104**. **FIG. 2** shows exemplary types of ATC policies **200** according to embodiments of the present invention.

The ATC policies (200) may be classified into different types such as geo-political policies **215**, load share policies **240**, failover policies **245**, tiered failover policies **250**, shedding policies **255**, regulatory policies **260**, and Classless Inter-Domain Routing (CIDR) block policies **210**.

These exemplary policies in the policy database **124** are described in greater detail below:

- **Geographic Policy (215):** Decisions are based on location of the end-user or an approximate thereof, e.g., using the IP address of an end-user's resolver. For example, if the IP address is within the U.S., the request may be directed to a "domestic" group of servers in the subscriber server network **104**, otherwise it may be directed to "international" servers in the network. The request may be directed to a proprietary Content Delivery Network (CDN) or to another service specified by the subscriber.

- **Load Share Policy (240)**: The subscriber can explicitly specify the amount of traffic (load share) to be directed to each of their servers within a defined server set in the subscriber server network **104**. Typically the load may be specified according to the capacity of each server. Based on such specification, the load share of each server may be derived as a percentage of the total load.
- **Failover policy (245)**: The subscriber may specify policies regarding a failover situation where some of the primary servers fail to function. To take care of such a scenario, a failover policy may instruct the ATC mechanism in terms of, for example, how often to monitor the availability of the servers and what strategy to adopt when a partial set of the primary servers are detected to be unavailable. For instance, a failover policy may specify to distribute the load of a failing server to other primary servers. It may also alternatively instruct the ATC framework to direct traffic to servers other than the primary servers.
- **Tiered Failover Policy (250)**: The subscriber may specify a strategy through tiered failover policies by which the load should be re-directed to servers at a next tier when one or more subscriber servers in a previous tier fail to function. For example, in defining the subscriber server network, each server group may be configured as a hierarchy, having the first tier of primary servers, the second tier of first layer overflow servers, and the third

tier of second layer overflow servers, etc. In this case, a tiered failover policy may be defined to indicate when the load should be re-directed from the primary servers to the overflow servers. For instance, a tiered failover policy may indicate that when all the primary servers fail, the load should be directed to the second tier, and when servers at both the first tier and the second tier fail, the load should be directed to the overflow servers at the third tier. The traffic may also be re-directed to some other servers. For example, when a content delivery network (CDN) is available, the traffic may be re-directed to the entire CDN.

- **Shedding Policy (255)**: In some circumstances, a fraction of the "load" originally designated to a server may be shed or re-directed to one or more different servers. This may occur when the amount of traffic directed to the subscriber server exceeds a prescribed level. In these cases, a subscriber-specified fraction of traffic (shed fraction) that would otherwise be directed to the server may be shed to one or more other different servers. Such strategy may be adopted to prevent catastrophic failure due to overload. The servers that take the shed load may be an overflow server or some other servers such as a content delivery network. An overload situation may be detected according to the response time of the server. For example, if the response time from a server becomes long, it may indicate that the server is overloaded. In this case, shedding policies 255 may be invoked to re-direct the traffic elsewhere. For instance, if there are a total of 3 primary servers in a server group with load share of (0.3, 0.3, 0.4) and the primary server that is designated to take 40% of the total load is completely overloaded, a shedding policy may specify to shed the load of this server by re-directing 50% of its original load to, for example, the servers located in the CDN **105**. A shedding policy may also specify a condition upon which the traffic will be directed again to the shedding server. Such a condition may relate to a desirable level of performance of the shedding server.

- **CIDR Policy (210)**: Policy decisions are supported based upon CIDR blocks of IP address space. CIDR denotes Classless Inter-Domain Routing, an IP addressing scheme that replaces the system based on classes A, B, and C. With CIDR, a single IP address can be used to designate many unique IP addresses.
- **Regulatory policy (260)**: Certain policies may be specified by some policy entities to control network traffic. Such policies may be enforced in system **100**.

A policy may be static or dynamic. Selection of a server from the subscriber server network **104** may be based on an adaptive, regularly updated map of the state of the Internet as well as adaptively updated policies. The map may cluster IP addresses together according to their network latency to a selected set of network agents. This enables the subscriber servers to be selected according to their "network proximity" to an end user's browser, optimizing resulted download time. The policies may be defined in such an adaptive manner that they reflect the dynamic status of the servers such as the availability and load.

Geo-political policies **215** may govern the selection of a server according to where the client is located. As shown in **FIG. 2**, the geo-political policies **215** may be further classified into continental based distribution policies **220**, country based distribution policies **225**, region based distribution policies **230** and time zone based distribution policies **235**. These policies may be set up to govern the process of selecting a particular server group according to different geographical or political criteria.

Geo-political policies differ from load based policies (described above). The former is designed to guide selections based on geographical criteria or time criteria. The latter concerns the selection process with respect to the dynamic capacity and load of the underlying servers. The load share policies **240** govern the selection according to the capacities of the servers. Partial failover or tiered failover policies (**245** and **250**) govern the traffic re-direction process when functioning servers in a server group are overloaded or failed.

The ATC policies **200** may be hierarchically constructed to form a decision tree. **FIG. 3** depicts an exemplary subscriber policy hierarchy or a decision tree built based on various types of subscriber policies, according to an embodiment of the present invention. In **FIG. 3**, the continental based distribution policies **220** are used to first direct a selection process limited to a particular continent. For example, if the requesting client **112** is located in Asia, the continental based distribution policies **220** may direct the further selection within servers that are located in Asia. Similarly, if the client **112** is located in either North America or Europe, the further selection process may be directed to the appropriate servers located in the corresponding continent.

Once a DNS request is directed to an appropriate continent, the country based distribution policies **225** may further constrain the selection to particular servers that are in the same or close-by countries where the client **112** is located. For example, if the client **112** is located in the U.S., the country based policies **225** may direct the selection from the servers located in the U.S. Similarly, the region based distribution policies **230** may further constrain the selection to, for example, the west coast or east coast depending on where the client **112** is located.

When a particular server group is selected (e.g., after a hierarchical decisions based on the continent-based policies **220** and the region-based policies **230**), the load share policies **240** govern the process whereby servers in a given server group should be selected. Such policies may be determined based on the servers' capacities or may be adaptively revised based on the dynamic performance or load of the underlying servers. The load share policies **240** may specify the percentage (share) of the total requests that each server in a server group should handle. For example, if a server group comprises a total of three primary servers (server 1, server 2, server 3), a load share policy for this server group may specify the load share as (0.3, 0.5, 0.2), indicating that server 1 should take 30% of the total load, server 2 should take 50% of the load, and server 3 should take 20% of the total load.

The tiered failover policies **250** govern the selection of a server when a particular default set of servers is no longer functioning or available. For example, primary servers in a server group may be considered as a default set of servers that provide service when operation is normal. Unavailability of such primary servers may be detected according to the response time of the server. For example, if a server is simply not responding, the server may be considered as not available. When all the primary servers are down, the tiered failover policies **250** govern where the traffic should be directed. For instance, the tiered failover policies **250** may specify to direct all traffic to the overflow servers at the next tier.

FIG. 4 depicts an exemplary relationship between the subscriber server network **104** and the subscriber policies **120**, according to embodiments of the present invention. The subscriber server network **104** is depicted in **FIG. 4** as a network hierarchy or a tree in which the subscriber server network **104** includes server group 1 **106-1** through server group *k* **106-*k***, and each server group may include its own primary server group **108** in the first tier and overflow server group **110** in the second tier (e.g., server group 1 **106-1** has primary server group **108-1** and overflow server group **110-1** associated therewith, while server group *k* **106-*k*** has primary server group **108-*k*** and overflow server group **110-*k*** associated therewith).

The subscriber policies **120** govern selection of one or more servers within the subscriber server network **104** (or in some other network of servers) so that their IP addresses may be returned in response to DNS requests from the client **112** (resolver **116**). To determine or to select appropriate servers in the subscriber server network **104**, the decisions may be hierarchical. For example, as shown in **FIG. 4**, at the level of the subscriber server network **104**, the ATC mechanism **126** may make geo-political distribution decisions **410** to determine which server group should be selected. Once a particular server group is selected, the ATC mechanism **126** may further determine which particular servers in the group should be selected according to, for example, how the traffic load should be shared among the servers within the server group. Decisions at server group level may be based on the load share policies **240**. This decision making process illustrates that, at each branch node in the server hierarchy, appropriate ATC policies may be applied to govern the selection of an appropriate server or servers.

As illustrated in **FIG. 4**, the geo-political policies **215** may be applied to control the selection of a particular server group, the load share policies **240**, the tiered failover policies **245** and **250**, and the shedding policies **255** may be applied to re-direct traffic. That is, the subscriber server network **104** forms a tree and the ATC policies **200** govern the flow from the top of the tree to one or more leaves of the tree. The ATC mechanism **126** controls the flow by applying the ATC policies **200**.

FIG. 5 depicts a high level architecture of an adaptive traffic control (ATC) framework according to embodiments of the present invention. The ATC framework comprises an ATC administrative framework **142** and an ATC name server network **140**. The ATC administrative framework **142** is responsible for various administrative tasks associated with subscribers or other policy making entities (**138**), include manipulating and storing the ATC policies **200**, propagating or broadcasting the ATC policies **200** to name servers in the ATC name server network **140**, monitoring name server behavior, generating status reports to display monitoring results on appropriate media, and sending alert to a network operation center (NOC) **148** (see **FIG.** 1) and the subscriber **102**.

The ATC name server network **140** is responsible for responding to DNS requests, including processing DNS requests, applying the ATC policies **200** to select one or more servers from the subscriber server network (or a different designated network), and replying with the IP address(es) of the selected server(s). The ATC name server network **140** dynamically maintains the ATC policies **200**, that are either received from the ATC administrative framework **142** or updated according to the dynamic operational status of the servers. The ATC name server network **140** provides domain name-IP address resolutions based on dynamically updated ATC policies **200**. The ATC name server network **140** may also monitor the operational status of individual name servers within the network and supply logging and monitoring data to the ATC administrative framework **142**.

The ATC administrative framework **142** may be designed to have fault-tolerance. For example, as depicted in **FIGS. 1** and **5**, the ATC administrative framework **142** may include an administrative master agent (AMA) **144**, and one or more AMA backups **146-1**, . . ., **146-*m*** (collectively **146**). All AMA agents, including the master agent **144** and the backups **146** may be capable of performing the exact functions except that one of them (e.g., master AMA **144**) may be a central or primary administrative master agent and others (e.g., AMA backups **146**) may be backup or secondary or redundant master agents.

The central or primary AMA **144** may be responsible for regularly backing up the AMA backup agents **146**. When, for whatever reason, the primary AMA **144** is no longer functioning properly, one of the AMA backups **146** may take on the role of the central or master AMA **144**.

The ATC name server network **140** may comprise a plurality of name server agents **118-1, 118-2, . . ., 118-*k***, each of which may be designed to be responsible for the DNS requests of a particular geographical (or any other administrative or functional) region. For example, the name server agent **118-1** may be responsible for processing all the DNS requests from North America, the name server **118-2** may be responsible for Europe's DNS requests, and the name server **118-3** may be responsible for DNS requests from Japan. In addition, a name server agent may also serve as a back up name server agent for other name server agents in the network. For example, if the North America name server agent is not functioning properly, the Europe name server agent may be temporarily assigned to handle the DNS requests from North America. For that purpose, all ATC policies may be propagated to all of the name server agents in the ATC name server network **140**.

FIG. 6 depicts a high level functional block diagram of an administrative master agent (AMA) **144** according to embodiments of the present invention. The AMA **144** comprises a secure web-based graphical user interface **160**, a policy editing mechanism **162**, an ATC policy database **124**, an administrative policy update mechanism **164**, an ATC administrative browser **166**, an ATC policy management mechanism **152**, a report generation mechanism **168**, an ATC network monitoring mechanism **150**, and an administrative master backup mechanism **170**.

The ATC policy database **124** stores the ATC policies **200**. As discussed above, the ATC policies **200** may include policies from different sources (e.g., from subscribers and from other entities that control network traffic). Both the subscriber policies **120** and other policies **122** may be defined and provided to the AMA **144**. In the exemplary configuration shown in **FIG. 6**, the policies may be received at the AMA **144** through the secure web based GUI **160**. There may be other means through which the policies can be delivered to the AMA **144** and will be discussed later. The policy editing mechanism **162** organizes the received policies to form the ATC policies **200** and then stores them in the ATC policy database **124**.

The ATC policy management mechanism **152** may broadcast or propagate the ATC policies **200** to relevant name servers in the ATC name server network **140** so that the ATC policies **200** may be used to control the domain name translation service. The stored ATC policies may be dynamically updated via different means. For example, the policies may be updated through the ATC administrative browser **166**, or the administrative policy update mechanism **164** may revise existing ATC policies.

Alternatively, the AMA 144 may also be provided with policies from different sources through the ATC policy management mechanism **152,** which may regularly poll dynamically updated policies from different locations. Such locations may include designated network locations that are designated to provide dynamic policy related information or servers (either in the subscriber server network **104** or in the CDN **105**) that are classified as managed servers. For instance, a server may dynamically specify its load share via a designated file stored on the server. To retrieve such dynamically defined load share information from a managed server, the ATC policy management mechanism **152** may poll the designated file stored on the managed server to obtain relevant load share information. Dynamic policies may also be polled from other policy making entities.

Broadcasting ATC policies may take place periodically according to some predefined interval or may be triggered whenever the stored ATC policies are updated. The

ATC policy management mechanism **152** may monitor changes made to the existing ATC policies. The ATC policy management mechanism **152** may poll the ATC policies stored in the ATC policy database and see whether there are changes. On the other hand, whenever the ATC policy management mechanism **152** polls dynamic policies from specified locations (such locations may be specified in existing ATC policies), it may determine whether the dynamically polled policies differ from existing ATC policies. In the event that updated policies are different from the existing ATC policies, the ATC policy management mechanism **152** may re-broadcast the updated ATC policies to the ATC name server network **140**.

The ATC network monitoring mechanism **150** may collect DNS log summaries from different name servers in the ATC name server network **140**. Such summary log data may be received in the form of events that provide information such as, for example, the number of requests directed to particular servers in a given time period. The ATC network monitoring mechanism **150** may collectively processes such DNS log summaries (or events) from the entire ATC system. The report generation mechanism **168** may generates monitoring status reports from these summaries and makes such reports available to the subscriber **102** via the secure web-based GUI **160**.

The administrative master backup mechanism **170** may periodically update the AMA backups **146-1, . . ., 146-*m*** to ensure that all the backup agents are current. This may include replicating the ATC policies, the operational status of various control mechanisms (including the ATC policy management mechanism **152**), the policy editing mechanism **162**, and the administrative policy update mechanism **164**, and providing the up-to-date information to the AMA backups.

A major function of an administrative master agent is to manage the ATC policies, to make sure that updated ATC policies are supplied to the name server agents in the ATC name server network **140**, to monitor the various name servers' performance, to generate dynamic monitoring status report of system performance, and to maintain a connection through which policies may be updated dynamically and monitoring report can be examined.

Information flagging system errors and other anomalous conditions is collected by the ATC network monitoring mechanism or agent **150**. **FIG. 7** depicts an internal functional block diagram of an ATC network monitoring mechanism **150**, according to embodiments of the present invention. The ATC network monitoring mechanism **150** includes a trap handler **176**, a processing mechanism **182**, and an alert generation mechanism **184**. The trap handler **176** traps events from the name servers in the name server network **140**. The processing mechanism **182** analyzes both the collected trapped events, and, based on analyzed information, the alert generation mechanism **184** generates alerts when necessary, and reports such alerts to, for example, the ATC's network operation center (NOC) **148** and the subscriber **102** (**FIG. 1**).

The trap handler **176** further comprises an event receiver **178** that intercepts trap events from the name servers and an event consolidation mechanism **180** which may classify the trapped events and organize them in a reasonable and appropriate fashion. The processing mechanism **182** may process the consolidated events to identify useful or informative patterns which may be further used, by the alert generation mechanism **184** to identify problematic patterns which may significantly affect the system performance.

The Adaptive Traffic Control (ATC) framework according to the present invention may be deployed as a stand-alone service directing traffic solely to the subscriber's servers, in conjunction with another content delivery network (CDN) provider, or in conjunction with any other service.

Each domain name server in the ATC name server network **140** may include (**FIG. 1**) a location determiner **128**, an adaptive traffic control (ATC) mechanism **126**, a monitoring agent or mechanism **130**, a database manager **132**, and a report generator **134**. When a name server (e.g., **118-1**) receives a request from the resolver **116** of the client **112**, the location determiner **128** determines the location of the resolver and sends such location information to the ATC mechanism **126**. Based on the location information, the ATC mechanism **126** retrieves relevant ATC policies from the policy database **124** (e.g., the subscriber policies **120** or the other policies **122**) and selects one or more servers in the subscriber server network **104** according to the retrieved relevant policies. The corresponding IP address(es) or the CNAME of the selected servers are then returned to the resolver **116**.

The database manager **132** maintains the policy database **124**. It received policies broadcast from the ATC policy management mechanism **152** in the ATC administrative framework **142** and populates the policies in the policy database **124**. The ATC policies received from the ATC administrative framework **142** may also include information that defines or classifies servers in the subscriber server network **104** (or in the CDN **105**). For example, some servers may be defined as monitored servers and some may correspond to managed servers.

When the database manager receive such information, it may inform the monitoring mechanism **130** of the classification of the underlying servers so that the monitoring mechanism **130** can monitor each server according to its status. When the ATC policy management mechanism **152** broadcasts updated policies, the database manager **132** accordingly updates the relevant policies stored in the policy database **124**.

The monitoring mechanism **130** monitors the operational status of the name server **118-1** and one or more servers in the subscriber server network. It may collect events occurred in the name server **118-1** during operations and send such events to the ATC network monitoring mechanism **150** in the ATC administrative framework **142**. On the other hand, it may also monitor the operations of various servers in the subscriber server group **104** (or in the CDN **105**) according to how each server is defined (monitored or managed server).

If a server is defined as a monitored server, the monitoring mechanism **130** may dynamically probe the server (as discussed earlier) to determine its availability. If a server is defined as a managed server, the monitoring mechanism **130** may monitor its availability during operation. The monitoring mechanism **130** may also poll dynamic load share information from the server. When the monitoring mechanism **130** detects that a server is no longer available, it may inform the database manager **132** to create a local policy that indicate that the server is no longer available so that the ATC mechanism **126** can take into account when resolving a hostname.

When the monitoring mechanism **130** polls the dynamic load share information from the server, it may inform the database manager **132** to update the load share policies in the policy database **124** that are affected by the dynamics of the polled load share. For example, if three primary servers in a server group originally have load share (0.3, 0.3, 0.4) and the third primary server now changes its load share to 0.2, the database manager **132** may accordingly update the load share among these three primary servers into (0.4, 0.4, 0.2).

The report generator **134** generates reports related to the operations of the underlying name server based on log information **136** recorded. Such generated reports may be sent to a report consolidator **154** in the ATC administrative framework **142** so that reports from different name servers may be consolidated.

A subscriber may activate (turn up) the ATC system (DNS servers) in one of two ways: using a DNS CNAME or using NS delegation. Instead of using ATC to direct traffic for a single DNS hostname, the subscriber may have many different subdomains that it would like to direct to ATC. For example, the subscriber might want all downloads from *dl.customer.com* handled by ATC, together with all of its subdomains, but have all other domains that it controls, such as *www.customer.com,* resolved by its own name server:

dl.customer.com. => ATC
any.thing.dl.customer.com. => ATC
www.customer.com. => not ATC
customer.com. => not ATC

In this case, instead of adding the CNAME record in the subscriber's DNS zone file, it simply delegates the *dl.customer.co*m. name to ATC via NS records in its zone file.

The delegation (using NS-records) method is presently preferred as it is more flexible and offers all of the reliability, scalability and flexibility of ATC. After the initial contact for delegation, a properly operating resolver making occasional queries will not contact the subscriber's own name server or name servers again. The result provides much better name resolution performance since the unnecessary overhead of routing each fresh DNS request through the subscriber's name server is eliminated. The CNAME method keeps the subscriber's own name server in the loop. That is, whenever the CNAME TTL expires, client resolvers will return to the subscriber's name servers to refresh the record.

[0001] For both CNAME and NS delegation methods, the procedure to turn off the ATC switch is the same – the subscriber edits its DNS zone files to remove the delegation authority to ATC. DNS requests will continue to be served in accordance with the subscriber's defined ATC policies until the TTL's have expired on the appropriate delegations.

The System in Operation

FIG. 8(a) is an exemplary flowchart of a process, in which a name server resolves a DNS request based on ATC policies, according to an embodiment of the present invention. First, a user enters a URL into the user's browser **114** (or into any application that accepts URLs as input and obtains the corresponding resource for the client) (at **802**). The client's resolver **116** attempts to resolve the hostname of the URL in order to obtain an IP address of a server from which the resource identified by the URL can be obtained (at **804**). The resolver **116** will be directed by the client's DNS (not shown) to a DNS Name Server **118** in the ATC name server network **134** (at **806**). The resolver **116** provides the name server **118** with the hostname it is attempting to resolve.

The name server **118** receives the request to resolve the hostname (at **808**) and determines one or more servers in the subscriber server network **104** or in the CDN **105** that can process the client's request according to the location of the resolver **116** as well as relevant ATC policies retrieved from the policy database **124** (at **810**). Details of this operation are described with reference to **FIG. 8(b)**. The IP address(es) of the selected server(s) are returned to the requesting resolver **116** (at **812**). The browser **114** then connects to one of the servers (at **814**) in order to obtain the requested resource.

FIG. 8(b) is a flowchart of an exemplary process, in which a domain name server selects one or more servers according to location of the client and relevant ATC policies. The location of the resolver **116** (or client) is first determined (at **816**). Relevant ATC policies are then retrieved (at **818**) from the policy database **124**. One or more servers in either the subscriber server network **104** or the CDN **105** are selected according to the determined location of the client and the relevant ATC policies (at **820**).

FIG. 8(c) is a flowchart of an exemplary process, in which the monitoring mechanism **130** in a domain name server monitors the operations of the name server as well as one or more servers in the subscriber server network **104** or the CDN **105**. Events occurring during domain name service are monitored (at **822**). Such events are sent to the ATC network monitoring mechanism **152** (at **824**). In addition, the availability of the one or more servers are also monitored (at **826**). Furthermore, if any of the one or more servers is defined as a managed server (determined at **828**), dynamic load share information is polled (at **830**). Both the availability information and the dynamic load share information (if any) are used to update some ATC policies that are local to the name server (at **832**).

FIG. 8(d) is a flowchart of an exemplary process, in which the ATC policy management mechanism **152** dynamically maintains and broadcasts the ATC policies. Initially, policies from different sources are received (at **834**) and broadcast to the name servers **118** (at **836**). If backup is necessary (determined at **838**), the ATC policy management mechanism **152** sends current policies to the master backup agents **146** (at **840**).

The ATC policy management mechanism **152** also performs dynamic policy maintenance. It polls dynamic policy information (at **842**) at certain defined intervals and uses such polled dynamic policy information to update existing policy (at **844**). The updated policies are then broadcast to the name servers (at **846**). If the updated policies need to be propagated to the backup agents (determined at **848**), they are sent to the master backup agents (at **850**).

FIG. 8(e) is a flowchart of an exemplary process, in which the ATC network monitoring mechanism **150** monitors operations of the name servers and sends alert to the NOC **148** and the subscriber **102**. Events sent from monitoring mechanisms of different name servers are trapped (at **852**). Such trapped events from different sources are then consolidated (at **854**) and processed (at **856**). If there is any alarming situation (determined at **858**), the ATC network monitoring mechanism **150** generates an alert (at **860**). The generated alert is then sent to both the NOC **148** and the subscriber **102** (at **862**).

Policy Administration

The ATC policies may be initially set up and later adaptively updated according to servers' dynamic operational status. The ATC policies may be formed via various means. The described approaches may also be applied to form other policies. A GUI approach or a file-based approach (or both) may be employed to set up subscriber policies. Through the GUI approach, different means to form subscriber policies may be adopted. For example, a browser may be used so that a subscriber can enter policies directly. An XML file containing descriptions of the subscriber policies may also be loaded using GUI approach so that the policies may be parsed and stored. As another alternative, a file containing descriptions of the subscriber policies may also be loaded in a similar fashion and parsed accordingly. When a file based method is used, a file containing descriptions of the subscriber policies, either constructed based on XML or some other structure, may be accessed via other means such as FTP.

In some preferred embodiments, a subscriber accesses a secure web-based GUI **160** (**FIG. 6**) using subscriber's secure browser interface **156**.

FIGS. 9(a)-9(c) show exemplary secure web based graphical interfaces, through which a subscriber may define load share policies and overflow policies with respect to specified network resources, according to embodiments of the present invention. There may be different types of load sharing servers: (1) static servers, (2) dynamic servers, and (3) overflow servers. A dynamic server is one that is specified as either a monitored or a managed server whose dynamic availability may be monitored and whose load may be re-directed when it becomes unavailable. In the case of a monitored server, both of its load share and load shed fraction may also be made dynamic.

Correspondingly, the policies governing routing requests to different types of servers may also be defined accordingly. First, the policies that govern static servers are applied when servers are relatively static and do not change often over time. This may mean that the availability of the servers is fairly stable and load sharing among different servers is also relatively stable. The policies that control dynamic servers are applied when servers are expected to change frequently. Such policies include failover policies, shedding policies, and tiered failover policies (described earlier). The overflow policies control the change of flow of the requests when, for some reason, primary servers, either static or dynamic, become unavailable or overloaded. In this case, relevant overflow policies determine to which overflow server a request for name service should be directed.

The load share with respect to a given server represents the amount of traffic that will be sent to that server within a static server setting. An exemplary method to compute the load share of the traffic sent to the server is to sum the load share amount of all servers in a current static server setting and divide the load share for that server by the summed total to derive the load share.

The shed fraction for a given server represents the percentage of traffic that should be redirected away from the server. The redirection may be carried out after load share is made based upon load share policies. FIG. 9(a) gives an example interface, in which each of the servers listed is assigned various selection related parameters. For example, for each server, a TTL is specified. In addition, a load share and a shed fraction may also be specified. For example, both server New York and London have load share of 1.0. The shed fraction assigned to server New York is 0.2, meaning that 20% of its load is re-directed to some other server, and the shed fraction assigned to server London is 0.3, meaning that 30% of its load is re-directed to some other server.

Shedding fractions may also be computed automatically on the fly. For example, when a server is detected to have slow response, indicating that it may be overloaded, a shedding fraction may be computed according to the discrepancy between its expected response time and the actual response time. Such an automatically computed shedding fraction can then be applied to re-direct the newly computed fraction of the traffic to a different server to unload some of the traffic originally intended to be directed to the overloaded server.

For each resource server, an on-line flag may also be set to indicate whether the server is currently available. This flag is shown in **FIG. 9(a)** in the rightmost column. With this flag, a server may be temporarily removed from the service, if, for instance, a server needs to be taken down for maintenance.

Due to the fact that dynamic servers are expected to change relatively frequently, policies that govern their selection may be defined in two stages. The policies for dynamic servers may be initially specified in a similar fashion as for static servers. For instance, load share and shed fraction can be defined for dynamic servers New York and London, as shown in **FIG. 9(a)**. During operation, however, the policies that govern the selection of dynamic servers may be established dynamically. For example, initially defined policies (e.g., load share, shed fraction, and on-line flag) may be adaptively revised based on, for instance, an on-line status report retrieved from one or more specified locations on the network. Dynamic policies provide considerable flexibility in how the selection may be conducted in a manner that is adaptive to the network health or any other network performance related factors (e.g., maintenance).

The on-line status report may be provided at one or more network locations specified by the subscriber. The locations may be specified as a Uniform Resource Locator (URL) and may be accessed through an HTTP request. A location of the status report may be specified in the initial policy, providing a constant link to the location. **FIG. 9(b)** shows an exemplary GUI for specifying an URL link to a status report. An URL link for the location of the status report is specified as " *http : // server*" which corresponds to a server named London with an IP address of 10.0.0.3. The access may be authenticated and such authentication requirements may also be specified in the initial policies. The on-line accessed status report may be constructed based on information gathered during monitoring the servers' performance. For instance, each server in the subscriber server network may provide a status report containing information related to its performance. Name servers in the ATC name server network may poll such information from such servers and such information may be used to update policies.

The frequency with which the status report is accessed may also be specified explicitly. For example, it may require the relevant mechanisms (specifically, the ATC policy management mechanism or the monitoring mechanism of each name server) to poll the status report at a regular time, e.g., every thirty seconds.

A status report may be constructed using some standard language such as extendible Markup Language (XML). Such a status report may contain revised policies, which may be determined by the subscriber manually based on network performance, devised by an automated process based on network performance, or may be generated by an individual managed server. In such cases, the status report includes updated policies and when it is polled, the updated policies are used in future traffic control. For example, a managed server may re-define its load share of according to its dynamic capacity. When such dynamically defined load share information is accessed and used in enforcement, the traffic is controlled in a manner that is adaptive to the network dynamics.

When a status report is accessed, the relevant mechanisms (e.g., the ATC policy management mechanism in the ATC administrative framework or the ATC mechanism in corresponding name server) updates the associated policies based on the information contained in the status report. For example, a status report may indicate that the current load share for server New York should be 0.4 (down from 1.0 previously) with the same shed fraction (0.2) and the current load share for server London should be 0.5 (down from previous 1.0) with 0.4 shed fraction (40% shed fraction). An alternative scenario may be that the status report provides network performance data about each dynamic server and the ATC mechanism, after accessing the status report, determines how the current policies may be revised accordingly.

When the status report provides dynamic policies, it may, in general include, for each dynamic server, the following information: `<ServerStatus loadShare="LS" shedFraction="SF" online="Boolean"/>`, where LS and SF represent numerical numbers and "Boolean" represents a logical value of either "true" or "false".

With the mechanism of dynamic policies described above, a subscriber or a server can easily specify changes to existing policies (e.g., changes to load share, shed fraction policies and the On-line flag) without having to update an entire ATC policy hierarchy. In addition, a parameter (called "Down on line" in some embodiments) can be set in an ATC policy to control the behavior of the ATC mechanism under the circumstance that the ATC policy management mechanism is unable to properly access the status report due to reasons such as a failed polling or retrieval or failing to parse the status report's content. According to some embodiments of the present invention, three different exemplary approaches may be applied to handle the situation.

With the first approach, a subscriber may instruct an ATC mechanism in a name server not to select a particular server if the status report for that server can not be properly obtained. The subscriber may specify this policy by setting parameter "Down on line" to false. In this case, the ATC mechanism will not consider the underlying server as a candidate for selection process until the polling mechanism retrieves a valid status report.

The second approach to deal with a polling failure is to allow the ATC mechanism to select the underlying dynamic server according to its default policies (or original policies). To specify this solution, the subscriber may set the "Down on line" parameter true.

The third approach to handle the situation where the status report can not be properly retrieved is to allow the ATC mechanism to select the underlying server if its "on line" flag is on (it is available). To achieve this, a subscriber may specify only the "on line" ServerStatus in the status report, with parameter "Down on line" set to either true or false. In this case, the ATC mechanism will use a load share and a shed fraction specified in the policy when the "On line" flag is set to true. The load share and the load shed fraction may both be dynamically determined (either broadcasted from the ATC policy management mechanism or polled by the ATC mechanism **130** from the underlying server.

Both static and dynamic servers are primary servers, although their selection may be controlled by operationally different policies. The third type of servers are called overflow servers. They provide alternatives when primary servers, for some reason, can not be selected. Typically, an overflow server corresponds to a Canonical name or *CName*, pointing to a service providing a CDN (such as, e.g., Cable & Wireless PLC's Footprint service). The choice of overflow servers may be determined based on the belief that they are in general always available. An overflow server may be defined through a window illustrated in **FIG. 9(c)**. In **Fig. 9(c)**, overflow servers are defined by a CName, which points to the CDN server address "*customer.footprint.net*" (e.g., the CDN **105**, shown in **FIG. 1**).

FIGS. 10(a) – 10(b) show example subscriber policies, defined based on a set of resource servers, that govern the selection of the servers according to different criteria such as geographical location of an incoming request and the time zone of each of the locations. In **FIG. 10(a)**, three different resource servers are defined, including an "eastserver" with IP address 10.0.0.2, a "westserver" with IP address 10.0.0.1, and a service network with CName "*customer.footprint.net*". Here, the service network may include more than one servers.

FIG. 10(b) shows an exemplary decision tree embedded in a set of geographical policies that guide how the traffic should be directed to a set of servers. In the decision tree depicted in **FIG. 10(b)**, the selection is first directed to different resources at the top level according to a split between the United States and rest of the world. A resource may correspond to either a single server (or CDN) or a group of servers (or CDNs). A request initiated from non-U.S. geographical regions is directed to a resource named "London". Within the United States, time zone based policies are further applied. A request initiated from a region within the central time zone is directed to a resource named "New Work". A request initiated from a region within Alaska time zone is directed to the resource "London". Finally, a request initiated from a region within the United States that does not fall in any of these time zones (i.e., Alaska or Central) can be directed to either "London" or "New York".

FIGS. 10(c) – 10(d) show another example decision tree constructed based on a set of resources (servers or CDNs) and subscriber policies that are defined based on geographical locations of an incoming request with overflow policies that allow the ATC mechanism to direct traffic to pre-defined overflow servers when primary servers are not available. In the Resource window shown in **FIG. 10(c)**, three resources are defined: static resources "London" and "New York", each defined based on its IP address, a service network named "Sydney" with CName "*customer.sandpiper.net*". Each resource may correspond to a set of servers such as a server group with certain hierarchy. Resource "London" is further defined as a dynamic resource and resource "Sydney" is further defined as an overflow server network nicknamed "cdn_service". **FIG. 10(d)** illustrates an example decision tree built based on these resources.

The decision tree in **FIG. 10(d)** first splits two ways at the top level based on whether a request is from the United States. When a request is initiated from the United States, it is directed, according to the policies illustrated in **FIG. 10(d)**, to the dynamic servers at the first tier of resource "London". A request from the United States may also directed to one of the overflow servers in resource "cdn_service". This may happen when either all the primary servers at the first tier of resource "London" fail to function or when such primary servers are overloaded.

In addition to the various web-based interfaces described herein, there are also other means through which subscriber policies may be defined. As discussed earlier, for example, subscriber policies may also be constructed or specified in an XML file which can be downloaded by an ATC mechanism and used to control the traffic.

Policies defined via different means (e.g., through web based GUI or XML file) may be converted into some pre-defined format within the ATC mechanism. Such pre-defined format may be designed for efficiency in manage and handling the ATC policies. For example, the internal format for ATC policies may be designed so that, internally, the AMAs can conveniently store, access, and broadcast the ATC policies to the name server agents and the name server agents can efficiently apply the policies.

As mentioned earlier, in addition to management of the ATC policies, the AMA may also monitor the performance of name servers and generates viewable DNS log reports. The monitoring mechanism may gather performance information from either the DNS logs of the name servers or the events trapped from the name servers. Such gathered information may be used by the report generation mechanism to construct informative reports. The report generation mechanism may also make such reports available to the subscribers via the secure web-based GUI. **FIGS. 11 (a) – 11(c)** show exemplary types of report information that is accessible via the secure web-based GUI. **FIG. 11(a)** depicts a web interface that allows a subscriber to view DNS log data of a specified resource server. A subscriber can specify the name of the server under review (e.g., "*download.subscriber.com*"), the form in which the log data is to be organized (e.g., specify output style of "Separate", meaning to display IP and CName queries and replies with answers as separate items in the output), the time period under review (e.g., from September 1, 2002 to September 24, 2002), and the time resolution used in displaying the log data (e.g., automatically select time resolution).

FIG. 11 (b) shows a plot of log data related to a specified server. The log data is presented in a plot, generated based on the log entries of a particular server against a specified period of time (X-axis) with certain resolution. The exemplary plot reflects the volume of the traffic directed to the underlying server during a period time between 2:30pm and 3:30pm on September 24, 2002. The traffic volume is described in terms of number of replies generated by the underlying server per minute (Y-axis). It can be seen in this example plot that there is a surge in traffic volume between 2:36pm and 2:38pm. **FIG. 11(c)** shows a graphical display for the same log data in **FIG. 11(b)** in a table form, in which the log data is listed in an chronicle order from top to the bottom of the table. For instance, each row in the left column lists a period of time. In the exemplary table, the log data within the one hour period (2:30pm to 3:30pm) is divided into a plurality of sub-periods, each of which is 15 minutes. For each sub-period, the third column provides the number of replies from the corresponding sub-period. For instance, during the sub-period of 3:15pm to 3:30pm, there are 13 replies and there is no reply in other sub-periods (consistent with the plot illustrated in **FIG. 11(b)**).

The various mechanisms described herein, including, without limitation, the adaptive traffic control (ATC) mechanism, the location determination mechanism, policy editing mechanism, administrative policy update mechanism, ATC policy management mechanism, report generation mechanism, a monitoring mechanism, and an administrative master backup mechanism may be implemented in hardware, software or a combination thereof. When implemented in software, they may be implemented in any type of appropriate interpreted or compiled programming language. When implemented fully or partially in software, aspects of the invention can reside on any memory or storage medium, including but not limited to a ROM, a disk, an ASIC, a PROM and the like. While the invention has been described with reference to particular mechanisms (algorithms, processes and functions) and architectures, one skilled in the art would realize that other mechanisms and/or architectures could be used while still achieving the invention.

When the various mechanisms of the present invention are running on a particular machine (e.g., the at a client or on a server), they may reside in the memory of the machine or on a storage device or in a combination. Further, while many of the operations have been shown as being performed in a particular order, one skilled in the art would realize that other orders, including some parallelization of operations, are possible and are considered to be within the scope of the invention.

[0002] The present invention has been described above in connection with a preferred embodiment thereof; however, this has been done for purposes of illustration only, and the invention is not so limited. Indeed, variations of the invention will be readily apparent to those skilled in the art. Such variations also fall within the scope of the invention. Thus, while the invention has been described with reference to the certain illustrated embodiments, the words that have been used herein are words of description, rather than words of limitation. Changes may be made, within the purview of the appended claims, without departing from the scope and spirit of the invention in its aspects. Although the invention has been described herein with reference to particular structures, acts, and materials, the invention is not to be limited to the particulars disclosed, but rather extends to all equivalent structures, acts, and, materials, such as are within the scope of the appended claims.

The processing described may be performed by a properly programmed general-purpose computer alone or in connection with a special purpose computer. Such processing may be performed by a single platform or by a distributed processing platform. In addition, such processing and functionality can be implemented in the form of special purpose hardware or in the form of software being run by a general-purpose computer. Any data handled in such processing or created as a result of such processing can be stored in any memory as is conventional in the art. By way of example, such data may be stored in a temporary memory, such as in the RAM of a given computer system or subsystem. In addition, or in the alternative, such data may be stored in longer-term storage devices, for example, magnetic disks, rewritable optical disks, and so on. For purposes of the disclosure herein, a computer-readable media may comprise any form of data storage mechanism, including such existing memory technologies as well as hardware or circuit representations of such structures and of such data.

What is claimed is:

1. A framework for delivery of Internet content comprising:

a subscriber server network; and

at least one domain name server constructed and adapted to provide policy-based domain name service,

wherein, in response to a request to resolve a hostname, the domain name server attempts to resolve the hostname to at least one address corresponding a server in the subscriber server network based on at least one policy consideration.

2. A framework as in claim 1 further comprising:

a content delivery network, distinct from the subscriber server network,

wherein, in response to a request to resolve a hostname, the domain name server provides at least one addresses of a server in the content delivery network based at least on a location of the requestor and other policy considerations.

3. A framework as in claim 1 wherein an address provided by the domain name server is selected based on one or more of:

(a) geographic policies;

(b) load share policies;

(c) overflow policies; and

(d) network aware policies.

4. The framework according to claim 1, wherein the at least one policy consideration includes at least one of:

a geo-political policy governing the selection of a server in the subscriber server network according to a geographical location of a requesting client;

a load share policy governing the selection of a primary server from a server according to dynamic load information associated with the servers in the subscriber server network;

a shedding policy governing a manner in which the load of a server in subscriber server network is to be shed to other servers in the subscriber server network;

a partial failover policy governing the selection of a server in subscriber server network when at least one primary server in the subscriber server network fails to function;

a failover policy governing the selection of a server at a next tier in a server hierarchy corresponding to a server group when servers in a previous tier fail to function; and

a server designation policy defining a server in the server network as one of a monitored server and a managed server.

5. A domain name server for providing domain name service comprising:

a location determiner for determining a location of a requestor;

an adaptive traffic control mechanism constructed and adapted to provide policy-based domain name service,

wherein, in response to a request to resolve a hostname, the domain name server attempts to provide at least one addresses of a server in a subscriber server network based on one or more of:

(a) geographic policies;

(b) load share policies;

(c) overflow policies; and

(d) network aware policies.

6. A method of providing domain name service comprising:

receiving from a resolver a request to resolve a hostname;

determining a location of the requesting resolver;

determining an address based on the determined location and on other dynamic policy considerations; and

providing the address to the requesting resolver.

7. A method as in claim 6 wherein the address is determined based on one or more of:

(a) geographic policies;

(b) load share policies;

(c) load shed policies; and

(d) network aware policies.

8. A framework for delivery of Internet content comprising:

a server network associated with a subscriber that provides Internet content; and

an adaptive traffic control (ATC) name server network having at least one domain name server constructed and adapted to provide policy-based domain name service,

wherein, in response to a request to resolve a hostname, at least one domain name server in the ATC name server network resolves the hostname to at least one address corresponding a server in the subscriber server network based at least one policy consideration.

9. A framework as in claim 8 wherein the policy considerations comprise one or more of:

(a) geographic policy considerations;

(b) load share policy considerations;

(c) overflow policy considerations; and

(d) network aware policy considerations.

10. A framework for adaptive traffic control comprising:

a server network; and

an adaptive traffic control (ATC) name server network having at least one domain name server constructed and adapted to provide adaptive policy-based domain name service, wherein,

in response to a request to resolve a hostname, at least one domain name server in the ATC domain name server network provides an answer based on a policy and on a location of the requestor.

11. A framework as in claim 10 wherein the answer comprises:

an Internet protocol (IP) address or a CNAME corresponding to a server in the server network.

12. The framework according to claim 10, wherein the server network includes at least one of:

a subscriber server network; and

a content delivery network.

13. The framework according to claim 12, wherein the subscriber server network comprises at least one server group, wherein each of the at least one server groups corresponds to a server hierarchy.

14. The framework according to claim 13, wherein the server hierarchy includes at least one of:

a first tier comprising at least one primary server;

a second tier comprising at least one first level overflow server that functions when the at least one primary server in the first tier fails to function; and

a third tier comprising at least one second level overflow server that functions when both the at least one primary server and the one or more first level overflow server fail to function.

15. The framework according to claim 14, wherein each server in the server network is at least one of:

a monitored server, wherein the availability of the monitored server is dynamically monitored; and

a managed server, wherein either the availability of the managed server is dynamically monitored, or the load share or the shed fraction of the managed server is defined dynamically.

16. The framework according to claim 15, wherein each domain name server in the ATC domain name server network comprises:

a location determiner constructed and adapted to determine a geographic location of a requesting client;

an adaptive traffic control (ATC) mechanism capable of facilitating the policy-based domain name service.

17. The framework according to claim 16, wherein the at least one policy includes at least one of:

a geo-political policy governing the selection of a server group in the server network according to a geographical location of the client;

a load share policy governing the selection of a server from a server group according to dynamic load share information associated with the servers in the server group;

a shedding policy governing how the load of a server in a server group is to be shed to other servers;

a failover policy governing the selection of a server at a tier of a server hierarchy when at least one of the servers at the same tier fail to function;

a tiered failover policy governing the selection of a server at a next tier in a server hierarchy when servers in a previous tier fail to function; and

a server designation policy defining a server in the server network as at least one of a monitored server and a managed server.

18. The framework according to claim 17, wherein the geo-political policy includes at least one of:

a continent-based policy;

a country-based policy;

a region-based policy; and

a time-zone based policy.

19. The framework according to claim 18, further comprising a regulatory policy.

20. The framework according to claim 16, wherein the domain name server further comprises a monitoring agent capable of observing events that occur during the operation of the domain name server.

21. The framework according to claim 20, wherein the monitoring agent is further constructed and adapted to monitor availability of one or more servers in the server network that are designated as either a monitored server or a managed server whereby the domain name server can determine the server according to the availability of the one or more servers.

22. The framework according to claim 21, wherein the monitoring agent is further capable of polling dynamic load share and load shed information from one or more managed servers so that the domain name server can determine a server according to the dynamic load share and load shed information associated with the managed servers.

23. The framework according to claim 20, further comprising an adaptive traffic control (ATC) administrative framework capable of administering the operations of the ATC name server network and the status of the server network.

24. The framework according to claim 23, wherein the ATC administrative framework comprises:

an administrative master agent (AMA);

at least one administrative master backup agent; and

a network operation center.

25. The framework according to claim 24, wherein the AMA comprises:

an ATC network monitoring mechanism capable of monitoring the operations of the ATC domain name server network through event information received from at least one monitoring agent of the at least one domain name server;

an ATC policy management mechanism capable of receiving and dynamically polling at least one policy from at least one source and broadcasting the at least one policy to the at least one domain name server in the ATC domain name server network; and

an administrative master backup mechanism capable of enabling the at least one administrative master agent backup to function in place of the AMA when the AMA fails to function.

26. The framework according to claim 25, wherein the at least one source includes at least one of:

the subscriber capable of interacting with the administrative master agent to define subscriber's policies and providing dynamic policies that can be polled by the ATC policy management mechanism;

one or more policy entities defining policies that can be received or dynamically polled by the ATC policy management mechanism; and

one or more managed servers in the server network that provide dynamic load share and load shed policies that can be polled.

27. The framework according to claim 25, wherein the ATC network monitoring mechanism comprises:

a trap handler capable of receiving event information from monitoring agents associated with different ATC domain name servers and consolidating the trapped event information;

a processing mechanism capable of analyzing the consolidated trapped event information; and

an alert generation mechanism capable of generating an alert according to the processing result from said processing and sending the alert to the network operation center.

28. The framework according to claim 27, wherein the alert generation mechanism is further capable of sending the alert to the subscriber.

29. A domain name server for resolving a hostname, comprising:

a location determiner capable of determining a geographic location of a client from which a request to resolve a hostname is received;

an adaptive traffic control (ATC) mechanism capable of supporting policy-based domain name service, wherein,

in response to the request from the client, the domain name server provides an answer which is at least one of an IP address and a CNAME of a server in a server network based at least on the location as ascertained by the location determiner and at least one policy.

30. The domain name server according to claim 29, wherein the server network includes at least one of:

a subscriber server network comprising at least one server group; and

a content delivery network comprising at least one server.

31. The domain name server according to claim 30, wherein each server group corresponds to a server hierarchy that includes at least one of:

a first tier comprising at least one primary server;

a second tier comprising one or more first level overflow servers that function when the at least one primary server fails to function; and

a third tier comprising one or more second level overflow servers that function when both the at least one primary server and the one or more first level overflow server fail to function.

32. The domain name server according to claim 29, wherein the at least one policy includes at least one of:

a geo-political policy governing the selection of a server group in the server network according to the geographical location of the client;

a load share policy governing the selection of a server from a server group according to dynamic load share information associated with the servers in the server group;

a shedding policy governing how the load of a server in a server group is to be shed to other servers;

a failover policy governing the selection of a server at a tier of a server hierarchy when at least one of the servers at the same tier fail to function;

a tiered failover policy governing the selection of a server at a next tier in a server hierarchy when servers in a previous tier fail to function; and

a server designation policy defining a server in the server network as at least one of a monitored server and a managed server.

33. The domain name server according to claim 32, wherein

a monitored server corresponds to a server where the availability of the monitored server is dynamically monitored; and

a managed server corresponds to a server where either the availability of the managed server is dynamically monitored or the load share and load shed is dynamically defined.

34. The domain name server according to claim 32, wherein the geo-political policies include at least one of:

a continent-based policy;

a country-based policy;

a region-based policy; and

a time-zone based policy.

35. The domain name server according to claim 32, further comprising a regulatory policy.

36. The domain name server according to claim 29, further comprising a monitoring agent capable of observing events occurred during the operation of the domain

name server and sending such events to an adaptive traffic control (ATC) network monitoring mechanism of an adaptive traffic control (ATC) administrative framework.

37. The domain name server according to claim 36, wherein the monitoring agent is further capable of monitoring the availability of one or more servers in the server network that are designated as either a monitored server or a managed server so that the domain name server can determine the server according to the availability of the one or more servers.

38. The domain name server according to claim 37, wherein the monitoring agent is further capable of polling dynamic load share and load shed information from one or more managed servers so that the domain name server can determine the server according to the dynamic load share and load shed information.

39. An adaptive traffic control (ATC) administrative framework, comprising:

an administrative master agent (AMA);

at least one administrative master agent (AMA) backup; and

a network operation center, wherein the AMA comprises:

an ATC network monitoring mechanism capable of monitoring the operations of an adaptive traffic control (ATC) domain name server network comprising at least one domain name server through event information received from at least one monitoring agent located in the at least one domain name server;

an ATC policy management mechanism capable of receiving and dynamically polling at least one policy from at least one source and broadcasting the at least one policy to the at least one domain name server; and an administrative master backup mechanism capable of enabling the at least one administrative master agent backup to function in place of the AMA when the AMA fails to function.

40. The framework according to claim 39, wherein the at least one source includes at least one of:

a subscriber capable of interacting with the administrative master agent to define subscriber's policies and providing dynamic policies that can be polled by the ATC policy management mechanism;

one or more policy entities capable of defining policies that can be dynamically polled by the ATC policy management mechanism; and

one or more servers in a server network that are designated as managed servers.

41. The framework according to claim 40, wherein the ATC network monitoring mechanism comprises:

a trap handler capable of receiving event information from monitoring agents located in different ATC domain name servers and consolidating the trapped event information;

a processing mechanism capable of analyzing the trapped event information; and

an alert generation mechanism capable of generating an alert according to the processing result from said processing and sending the alert to the network operation center and the subscriber.

42. A method for adaptive traffic control based domain name service, comprising:

receiving, by a domain name server in an adaptive traffic control (ATC) domain name server network, a request from a resolver to resolve a hostname;

determining an answer corresponding to a server in a server network based at least on the geographic location of the client and at least one policy; and

causing the answer to be provided to the requestor, wherein the answer is at least one of the IP address and the CNAME of a server in a server network.

43. The method according to claim 42, wherein the server network includes at least one of:

a subscriber server network providing content delivery service; and

a content delivery network providing the content delivery service.

44. The method according to claim 43, wherein the subscriber server network includes at least one server group.

45. The method according to claim 44, wherein each server group corresponds to a server hierarchy that includes at least one of:

a first tier comprising at least one primary server;

a second tier comprising one or more first level overflow servers that function when the at least one primary server fails to function; and

a third tier comprising one or more second level overflow servers that function when both the at least one primary server and the one or more first level overflow servers fail to function.

46. The method according to claim 45, wherein each server in the server network can be designated as at least one of:

a monitored server, wherein the availability of the monitored server is dynamically monitored; and

a managed server, wherein either the availability of the managed server is dynamically monitored or the load share or the load shed of the managed server is dynamically defined.

47. The method according to claim 46, wherein the at least one policy includes one or more of:

a geo-political policy governing the selection of a server group in the server network according to the geographical location of the client;

a load share policy governing the selection of a server from a server group according to dynamic load share information associated with the servers in the server group;

a shedding policy governing how the load of a server in a server group is to be shed to other servers;

a failover policy governing the selection of a server at a tier of a server hierarchy when at least one of the servers at the same tier fail to function;

a tiered failover policy governing the selection of a server at a next tier in a server hierarchy when servers in a previous tier fail to function; and

a server designation policy defining a server in the server network as at least one of a monitored server and a managed server.

48. The method according to claim 47, wherein the geo-political policy includes at least one of:

a continent-based policy;

a country-based policy;

a region-based policy; and

a time-zone based policy.

49. The method according to claim 48, further comprising a regulatory policy.

50. The method according to claim 49, wherein said determining the IP address comprises:

determining the geographic location of the client;

retrieving one or more policies relevant to the geographic location of the client;

identifying the server according to the retrieved one or more policies; and

identifying the at least one of the IP address and the CNAME of the server.

51. The method according to claim 50, further comprising establishing the at least one policy.

52. The method according to claim 51, wherein said establishing the at least one policy comprises at least one of:

receiving, by an adaptive traffic control (ATC) policy management mechanism of an administrative master agent (AMA) in an adaptive traffic control (ATC) administrative framework, the at least one policy from at least one source;

dynamically polling the at least one policy from one or more managed servers in the server network.

53. The method according to claim 52, wherein the at least one source includes at least one of:

the subscriber; and

a regulatory entity.

54. The method according to claim 53, further comprising broadcasting the at least one policy to the at least one domain name server in the ATC name server network.

55. The method according to claim 54, further comprising:

dynamically updating a policy based on a dynamic policy polled by said polling to generate an updated policy; and

broadcasting the updated policy to the at least one domain name server in the ATC name server network.

56. The method according to claim 55, further comprising monitoring, by a monitoring mechanism in a domain name server, the operational status of the domain name server.

57. The method according to claim 56, wherein said monitoring comprises:

monitoring events that occur during the operations of the domain name server; and

sending the events to an ATC network monitoring mechanism in the ATC administrative framework.

58. The method according to claim 57, further comprising monitoring, by the monitoring mechanism, the availability of one or more servers that are designated as either

a monitored server or a managed server so that the domain name server can determine the server according to the availability of the one or more servers.

59. The method according to claim 58, further comprising polling, by the monitoring mechanism, dynamic load share or load shed information from one or more managed servers in the server network so that the domain name server can determine the server according to the dynamic load share and load shed information.

60. The method according to claim 59, further comprising administering, by the ATC administrative framework, the operational status of the ATC name server network.

61. The method according to claim 60, wherein said administering comprises:

receiving events from monitoring mechanisms of the domain name servers in the ATC name server network;

consolidating, by the ATC network monitoring mechanism, the events received from the domain name servers to generate consolidated events; and

processing the consolidated events.

62. The method according to claim 61, further comprising:

generating an alert based on results from said processing; and

sending the alert to an network operation center of the ATC administrative network and the subscriber.

63. A method for resolving a hostname, comprising:

receiving, by a domain name server in an adaptive traffic control (ATC) name server network, a request to resolve a hostname from a client via a resolver;

determining a server in a server network based at least on the geographic location of the client and at least one policy; and

determining at least one of an IP address and a CNAME of the server based on the determined location at least one location based policy.

64. The method according to claim 63, wherein the server network includes at least one of:

a subscriber server network; and

a content delivery network.

65. The method according to claim 64, wherein the subscriber server network includes at least one server group.

66. The method according to claim 65, wherein each server group corresponds to a server hierarchy that includes at least one of:

a first tier comprising at least one primary server;

a second tier comprising one or more first level overflow servers that function when the at least one primary server fails to function; and

a third tier comprising one or more second level overflow servers that function when both the at least one primary server and the one or more first level overflow servers fail to function.

67. The method according to claim 66, wherein each server in the server network is at least one of:

a monitored server, wherein the availability of the monitored server is dynamically monitored; and

a managed server, wherein either the availability of the managed server is dynamically monitored or the load share or the load shed of the managed server is dynamically defined.

68. The method according to claim 67, wherein the at least one policy includes one or more of:

a geo-political policy governing the selection of a server group in the server network according to the geographical location of the client;

a load share policy governing the selection of a server from a server group according to dynamic load share information associated with the servers in the server group;

a shedding policy governing how the load of a server in a server group is to be shed to other servers;

a failover policy governing the selection of a server at a tier of a server hierarchy when at least one of the servers at the same tier fail to function;

a tiered failover policy governing the selection of a server at a next tier in a server hierarchy when servers in a previous tier fail to function;

a server designation policy defining a server in the server network as at least one of a monitored server and a managed server; and

a regulatory policy.

69. The method according to claim 68, wherein said determining the server comprises:

determining the geographic location of the client;

retrieving one or more policies relevant to the geographic location of the client; and

determining the server according to the retrieved one or more policies.

70. The method according to claim 69, further comprising dynamically establishing the at least one policy.

71. The method according to claim 70, wherein said establishing the at least one policy comprises at least one of:

receiving the at least one policy broadcasted from an adaptive traffic control (ATC) policy management mechanism of an administrative master agent (AMA) in an adaptive traffic control (ATC) administrative framework; and

dynamically polling one or more load share or load shed policies from one or more managed servers in the server network; and

updating a policy based on a corresponding dynamic policy that is either received from the ATC policy management mechanism or polled from a managed server to generate an updated policy.

72. The method according to claim 71, further comprising monitoring, by a monitoring mechanism of the domain name server, the operational status of the domain name server.

73. The method according to claim 72, wherein said monitoring comprises:

monitoring events that occur during the operations of the domain name server;

sending the events to an ATC network monitoring mechanism in the ATC administrative framework.

74. The method according to claim 73, further comprising monitoring the availability of one or more servers that are designated as wither a monitored server or a managed server so that the domain name server can determine the server according to the availability of the one or more servers.

75. A method of an adaptive traffic control (ATC) administrative framework, comprising:

maintaining at least one policy used by at least one domain name server in an adaptive traffic control (ATC) name server network to determine the IP address of a server in a server network in response to a request from a client to resolve a hostname;

monitoring the operational status of the ATC name server network.

76. The method according to claim 75, wherein said maintaining the at least one policy comprises:

receiving, by an adaptive traffic control (ATC) policy management mechanism of an administrative master agent (AMA) in the ATC administrative framework, the at least one policy from at least one source; and

broadcasting the received at least one policy to the at least one domain name server in the ATC name server network.

77. The method according to claim 76, wherein the at least one source includes at least one of:

a subscriber; and

a regulatory entity.

78. The method according to claim 77, further comprising:

polling one or more load share or load shed policies from one or more servers that are designated as managed servers in the server network;

updating a policy using a corresponding dynamic policy that is either received from the at least one source or polled from a managed server to generate an updated policy; and

broadcasting the updated policy to one or more domain name servers in the ATC name server network.

79. The method according to claim 78, wherein said monitoring comprises:

receiving, by an ATC network monitoring mechanism in the ATC administrative framework, events sent from at least one monitoring mechanism of the at least one domain name server;

consolidating the events to form consolidated events; and

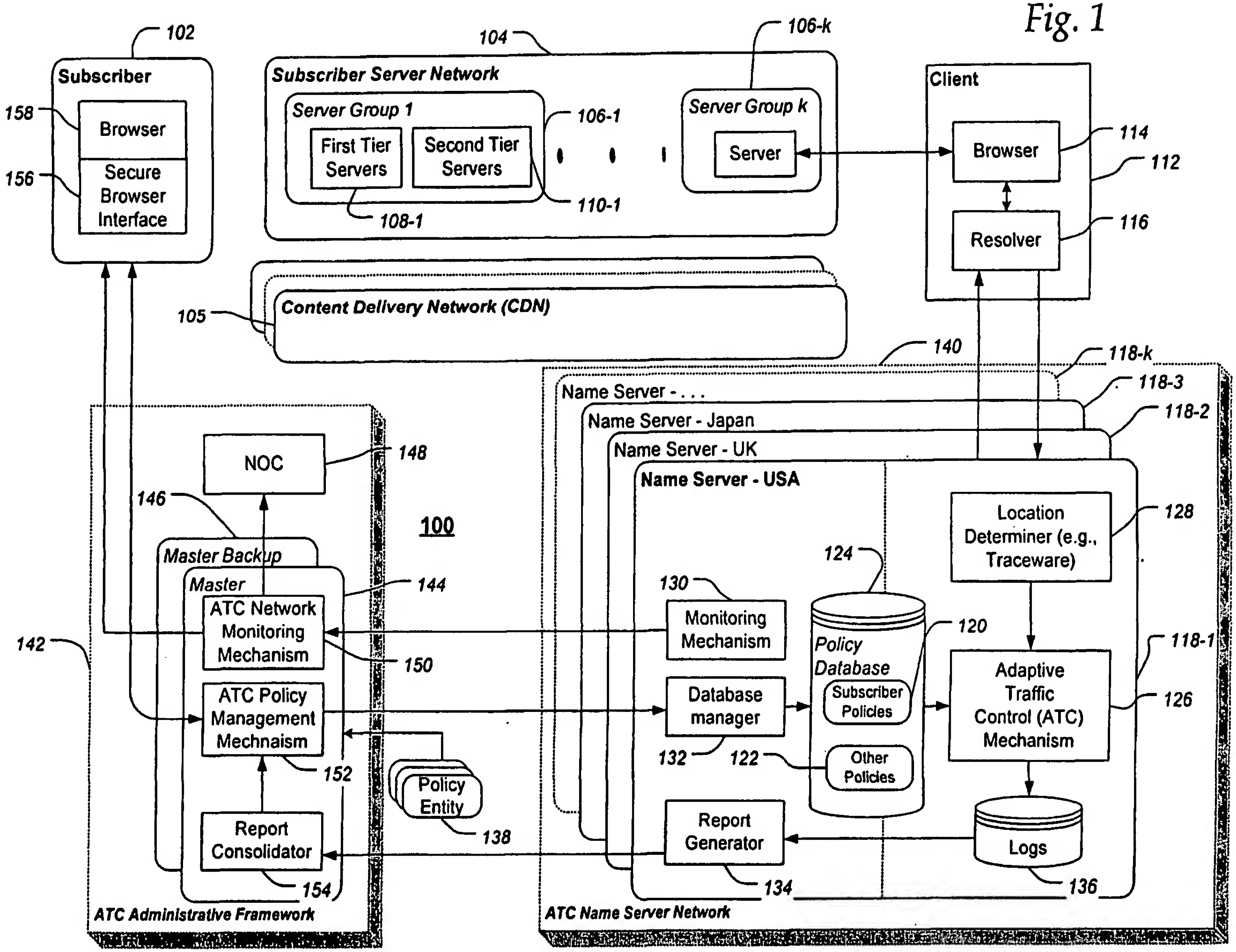
processing the consolidated events.

80. The method according to claim 79, further comprising:

generating an alert based on results from said processing; and

sending the alert to an network operation center of the ATC administrative framework and the subscriber.

Fig. 1


102
Subscriber
158
Browser
156
Secure Browser Interface
104
Subscriber Server Network
Server Group 1
First Tier Servers
Second Tier Servers
108-1
106-1
110-1
106-k
Server Group k
Server
Client
Browser
114
112
Resolver
116
105
Content Delivery Network (CDN)
140
118-k
118-3
118-2
Name Server - . . .
Name Server - Japan
Name Server - UK
Name Server - USA
NOC
148
146
100
Master Backup
Master
144
ATC Network Monitoring Mechanism
150
ATC Policy Management Mechnaism
152
Report Consolidator
154
142
Policy Entity
138
ATC Administrative Framework
Location Determiner (e.g., Traceware)
128
124
130
Monitoring Mechanism
Policy Database
Subscriber Policies
Other Policies
120
Adaptive Traffic Control (ATC) Mechanism
118-1
126
Database manager
132
122
Report Generator
134
Logs
136
ATC Name Server Network

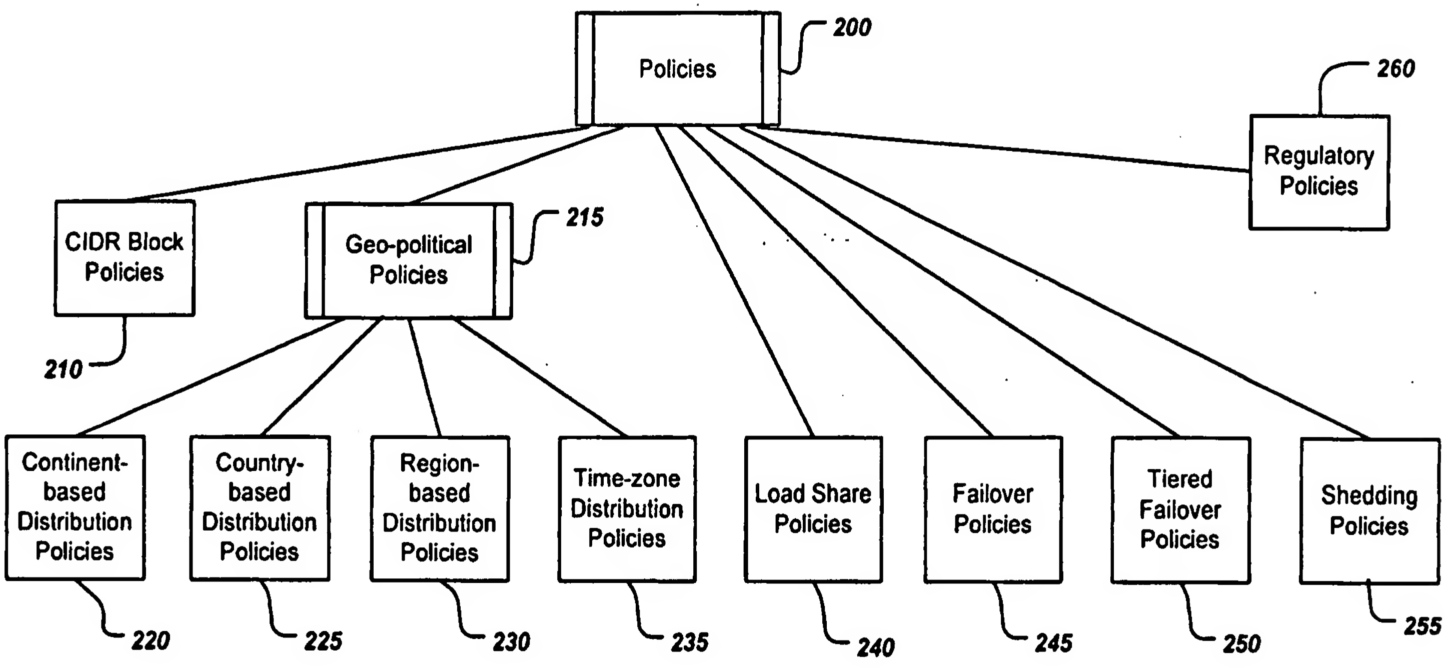

Policies
200
Regulatory Policies
260
CIDR Block Policies
210
Geo-political Policies
215
Continent-based Distribution Policies
220
Country-based Distribution Policies
225
Region-based Distribution Policies
230
Time-zone Distribution Policies
235
Load Share Policies
240
Failover Policies
245
Tiered Failover Policies
250
Shedding Policies
255

Fig. 2

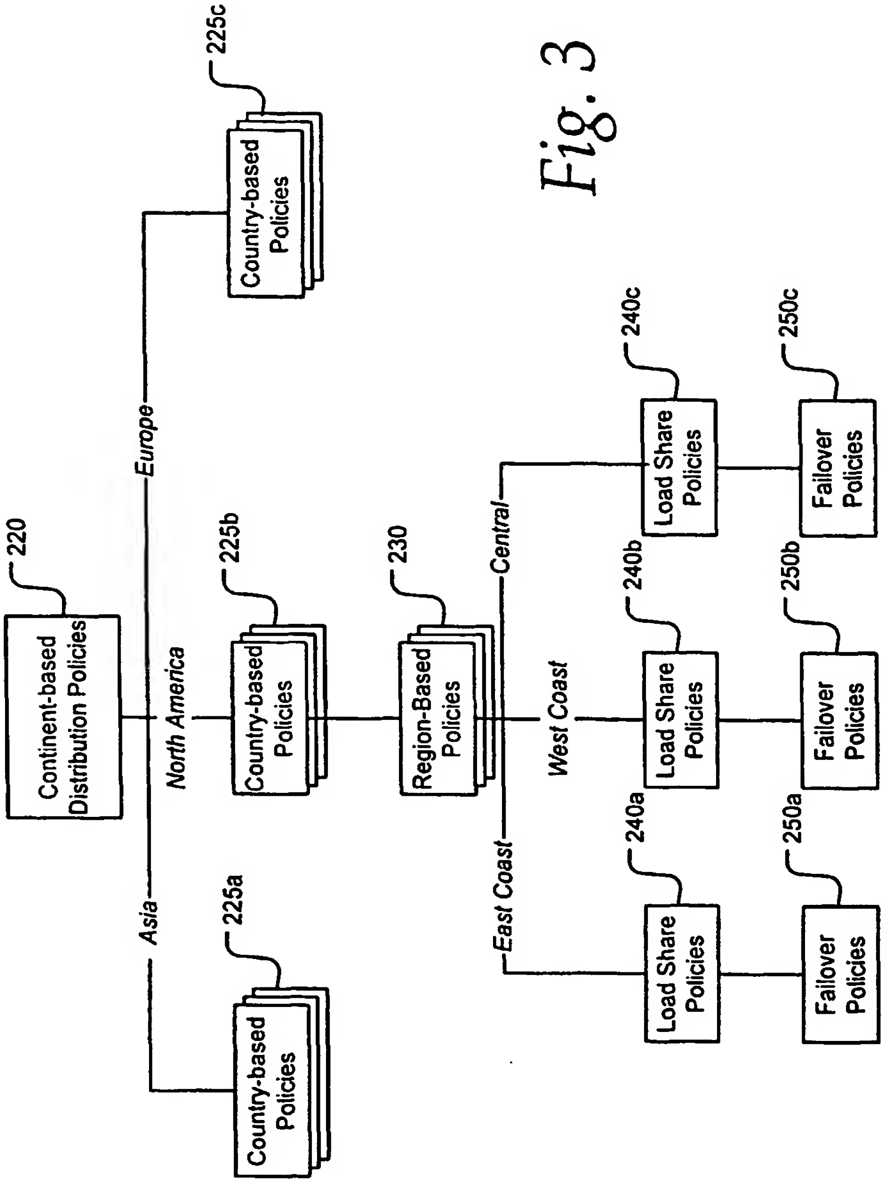

220
Continent-based Distribution Policies
Asia
North America
Europe
225a
Country-based Policies
225b
Country-based Policies
225c
Country-based Policies
230
Region-Based Policies
East Coast
West Coast
Central
240a
Load Share Policies
240b
Load Share Policies
240c
Load Share Policies
250a
Failover Policies
250b
Failover Policies
250c
Failover Policies

Fig. 3

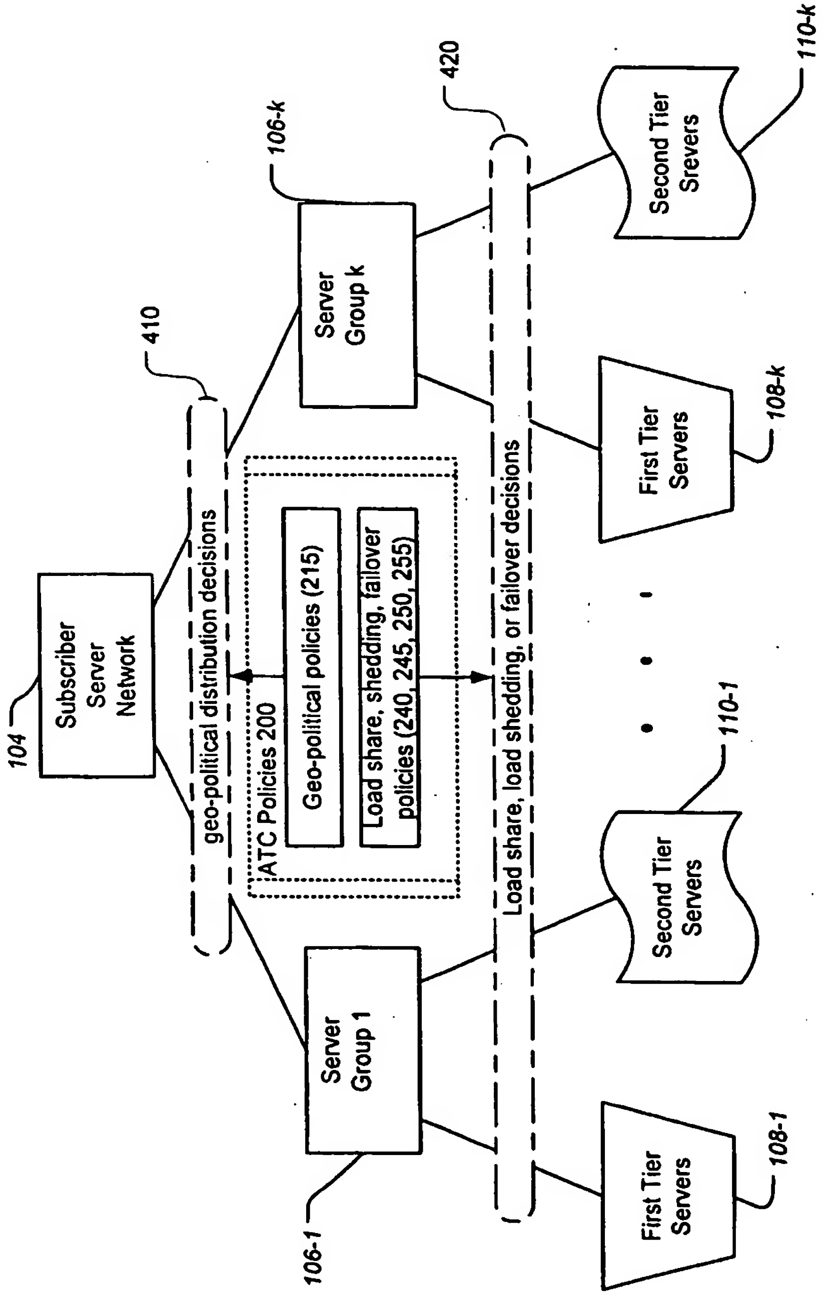

104
Subscriber Server Network
410
geo-political distribution decisions
ATC Policies 200
Geo-political policies (215)
Load share, shedding, failover policies (240, 245, 250, 255)
106-1
Server Group 1
106-k
Server Group k
420
Load share, load shedding, or failover decisions
First Tier Servers
108-1
Second Tier Servers
110-1
First Tier Servers
108-k
Second Tier Srevers
110-k

Fig. 4

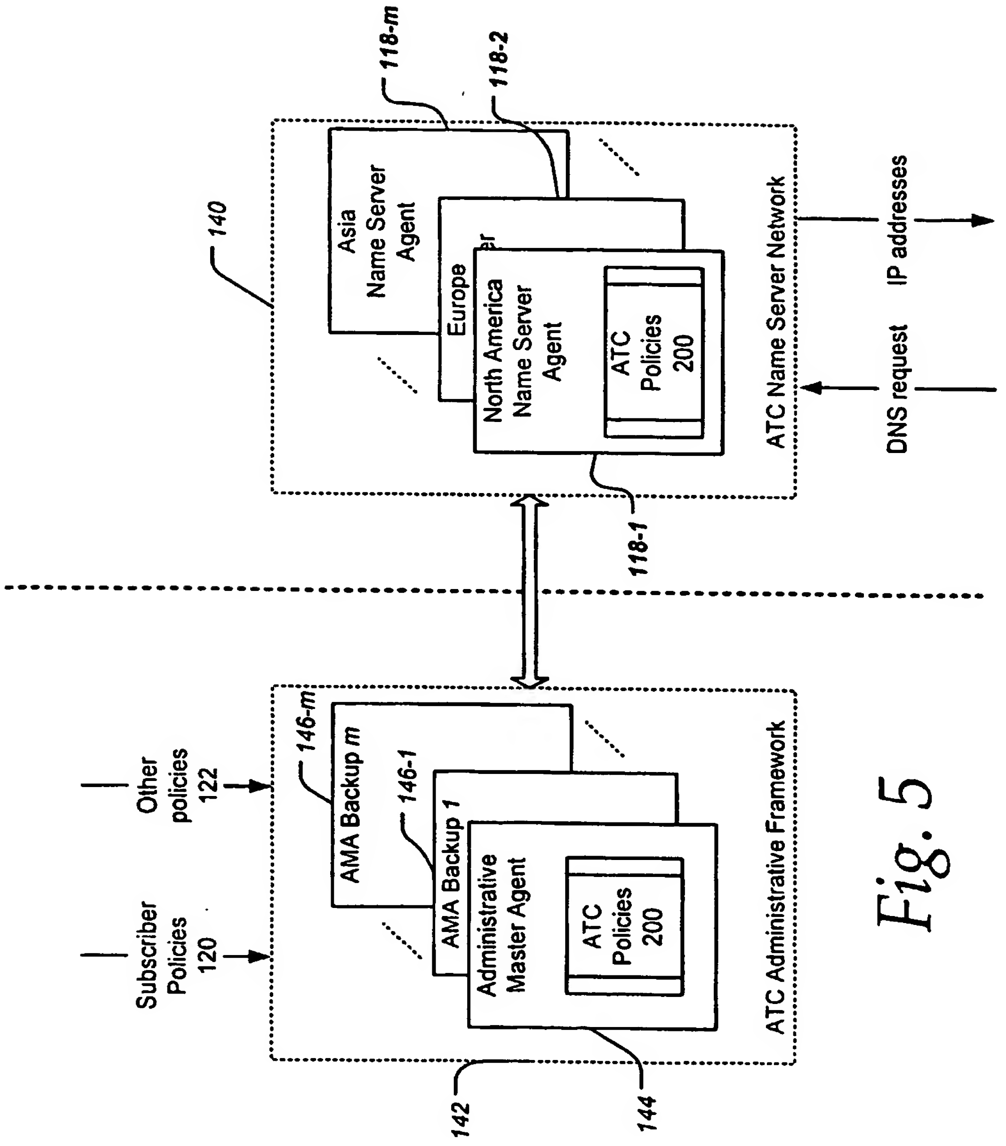

140
118-m
118-2
Asia
Name Server
Agent
Europe
North America
Name Server
Agent
ATC
Policies
200
118-1
ATC Name Server Network
DNS request
IP addresses
Subscriber
Policies
120
Other
policies
122
146-m
AMA Backup m
146-1
AMA Backup 1
Administrative
Master Agent
ATC
Policies
200
ATC Administrative Framework
142
144

Fig. 5

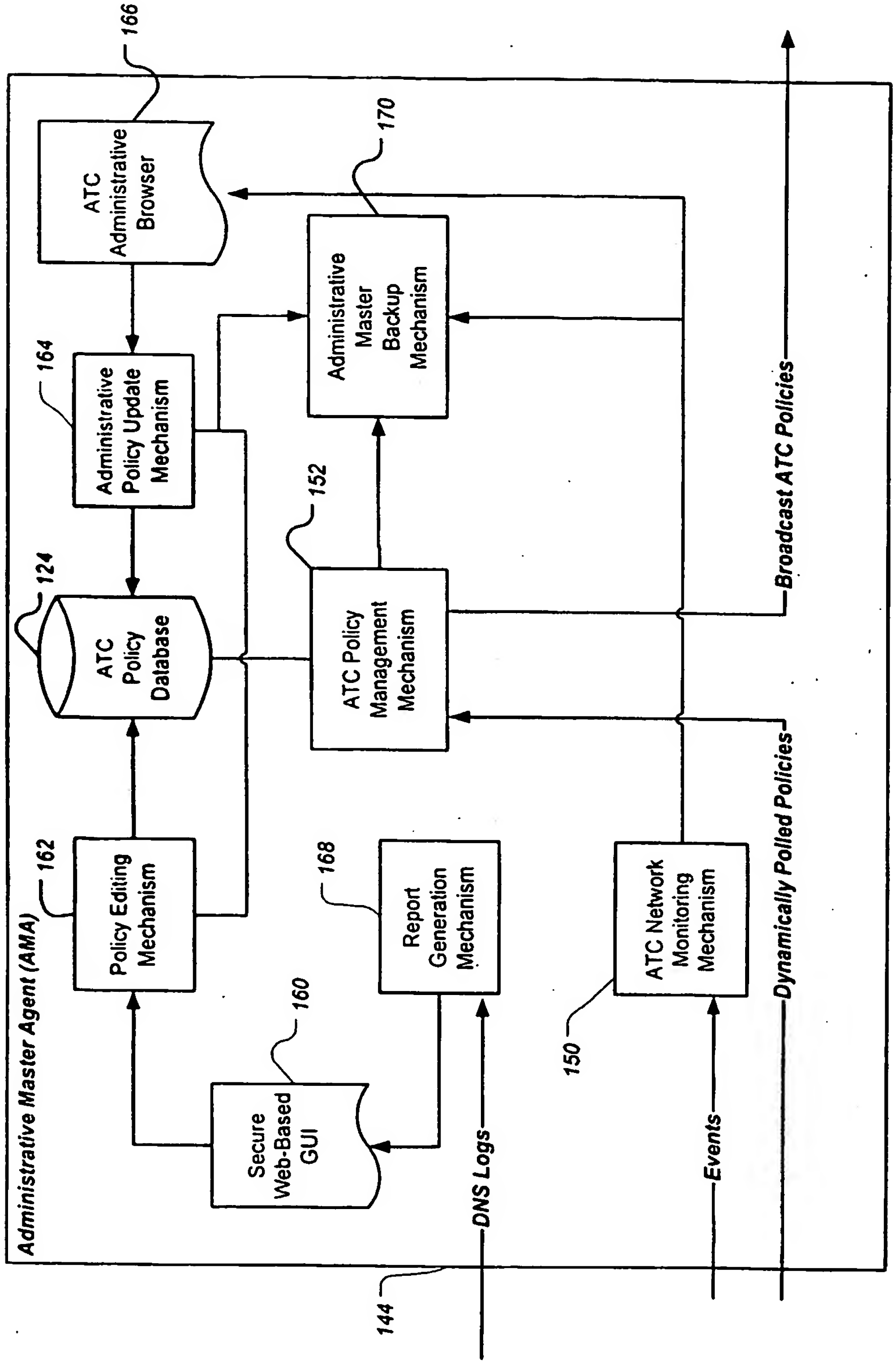

Administrative Master Agent (AMA)
144
ATC Administrative Browser
166
Administrative Policy Update Mechanism
164
Administrative Master Backup Mechanism
170
ATC Policy Database
124
ATC Policy Management Mechanism
152
Policy Editing Mechanism
162
Report Generation Mechanism
168
Secure Web-Based GUI
160
ATC Network Monitoring Mechanism
150
DNS Logs
Events
Dynamically Polled Policies
Broadcast ATC Policies

Fig. 6

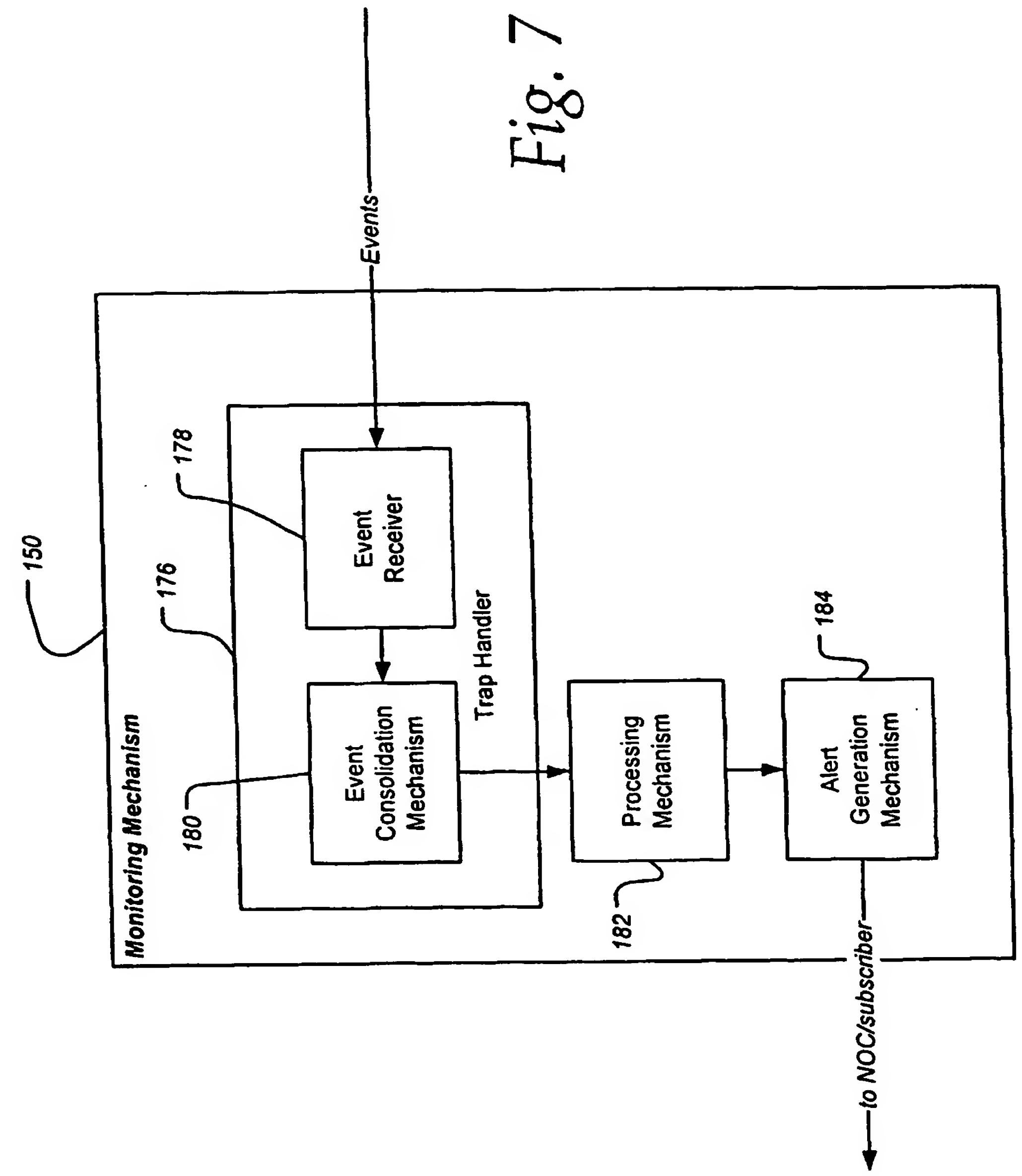

Events
150
Monitoring Mechanism
176
178
Event Receiver
180
Event Consolidation Mechanism
Trap Handler
Processing Mechanism
182
184
Alert Generation Mechanism
to NOC/subscriber

Fig. 7

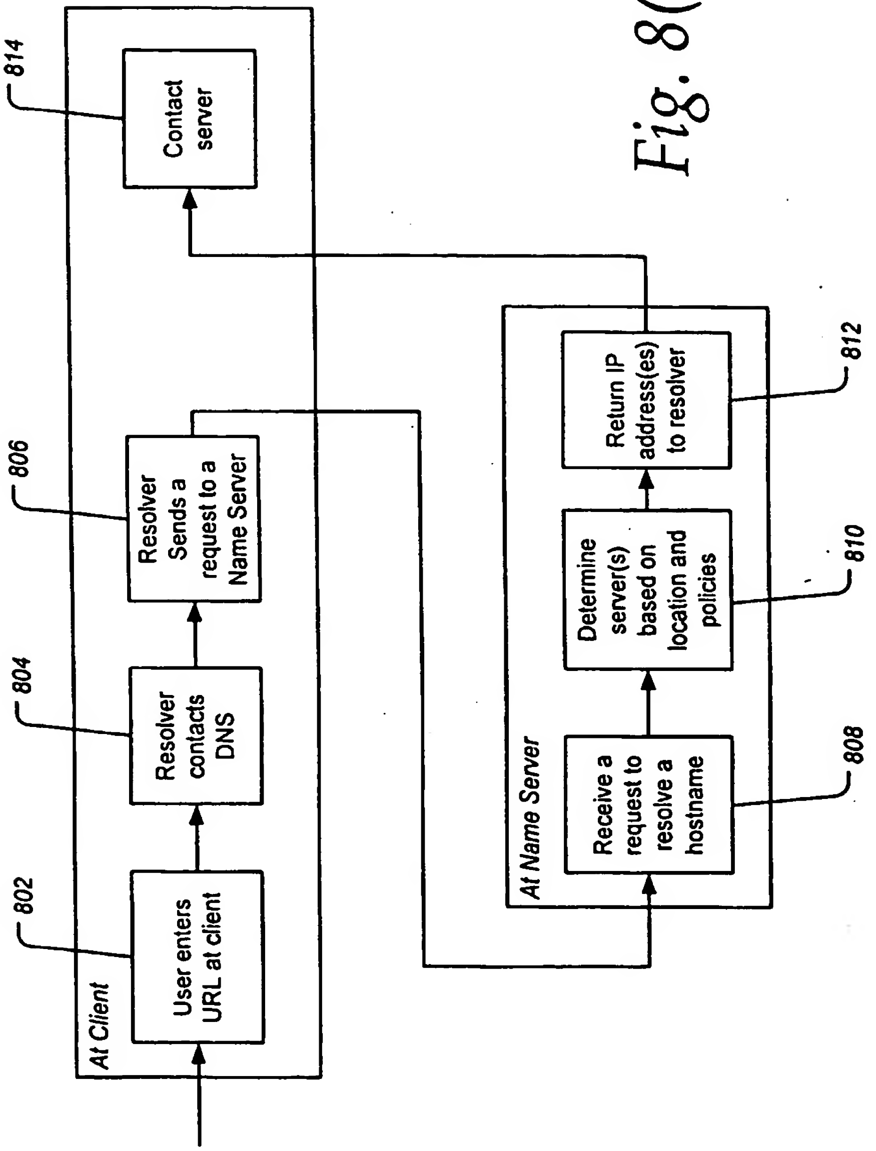

At Client
User enters URL at client
802
Resolver contacts DNS
804
Resolver Sends a request to a Name Server
806
Contact server
814
At Name Server
Receive a request to resolve a hostname
808
Determine server(s) based on location and policies
810
Return IP address(es) to resolver
812

Fig. 8(a)

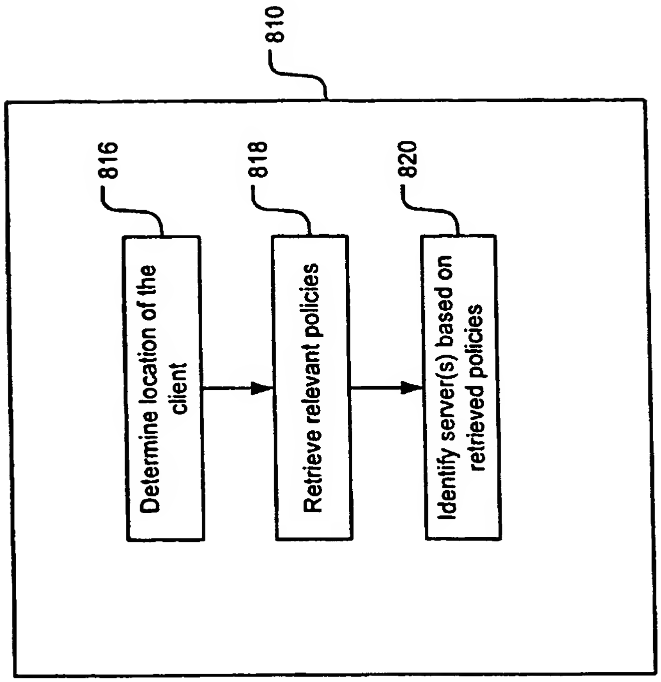

810
816
Determine location of the client
818
Retrieve relevant policies
820
Identify server(s) based on retrieved policies

Fig. 8(b)

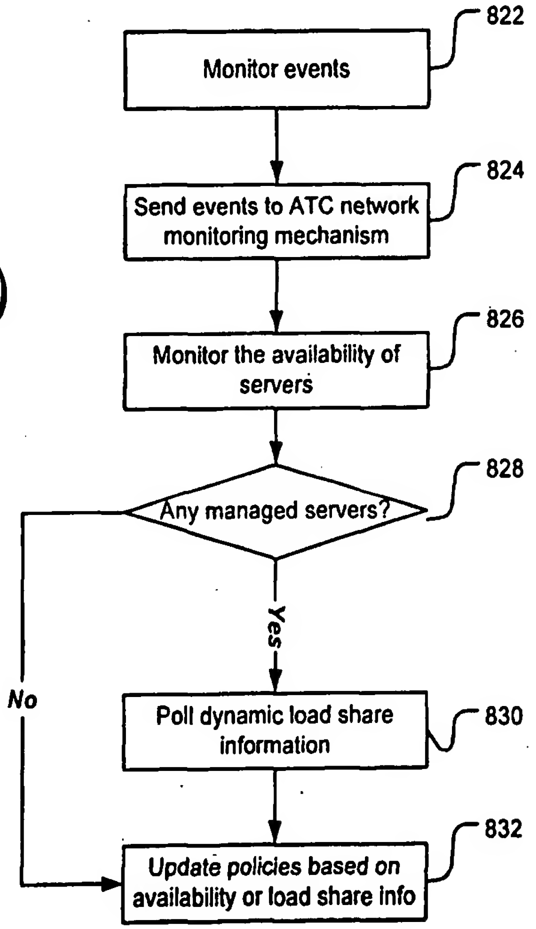

822
Monitor events
824
Send events to ATC network monitoring mechanism
826
Monitor the availability of servers
828
Any managed servers?
Yes
No
830
Poll dynamic load share information
832
Update policies based on availability or load share info

Fig. 8(c)

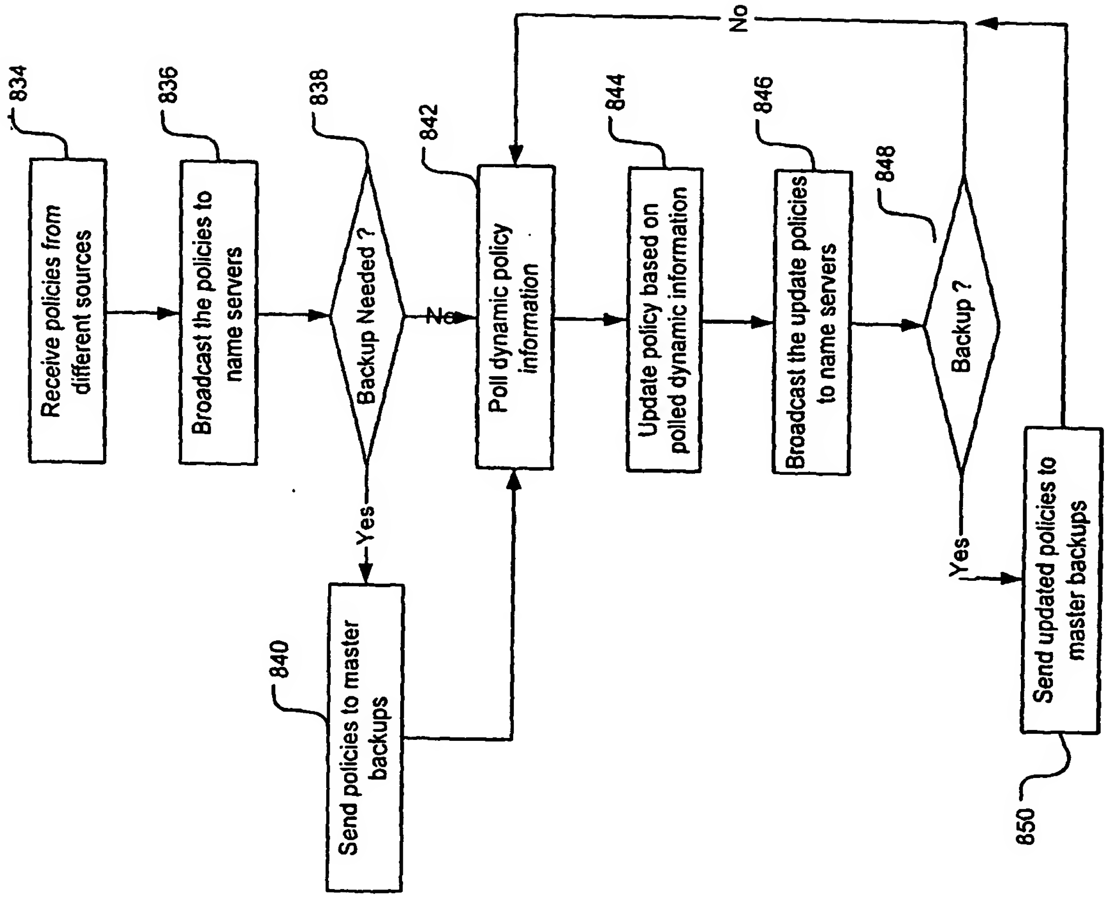

834
Receive policies from different sources
836
Broadcast the policies to name servers
838
Backup Needed ?
Yes
840
Send policies to master backups
No
842
Poll dynamic policy information
844
Update policy based on polled dynamic information
846
Broadcast the update policies to name servers
848
Backup ?
No
Yes
850
Send updated policies to master backups

Fig. 8(d)

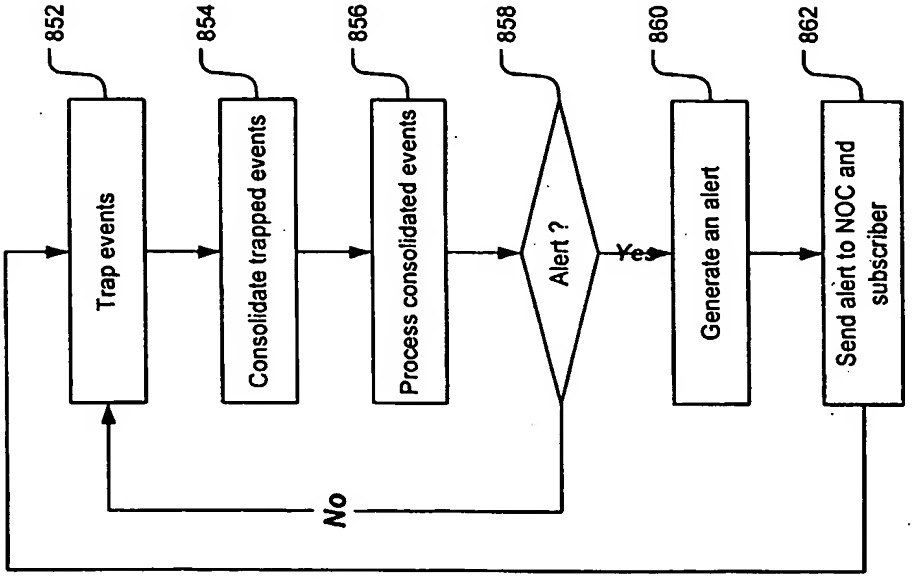
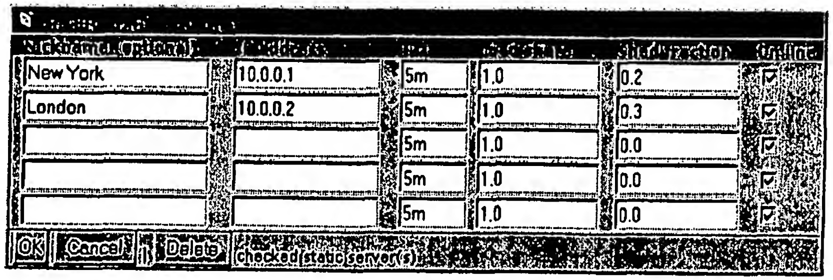

852
Trap events
854
Consolidate trapped events
856
Process consolidated events
858
Alert ?
Yes
No
860
Generate an alert
862
Send alert to NOC and subscriber

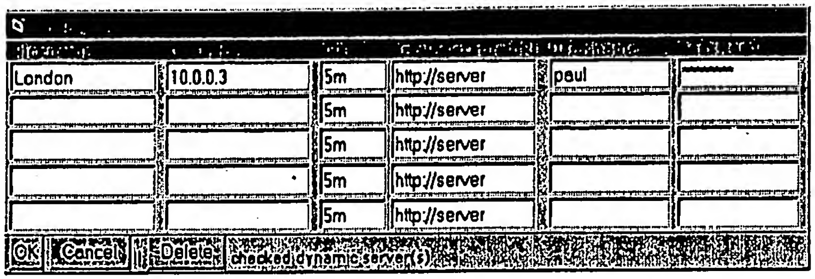
Fig. 8(e)



Nickname (optional)	IP address	TTL	[illegible]	Shed fraction	Online
New York	10.0.0.1	5m	1.0	0.2	☑
London	10.0.0.2	5m	1.0	0.3	☑
		5m	1.0	0.0	☑
		5m	1.0	0.0	☑
		5m	1.0	0.0	☑

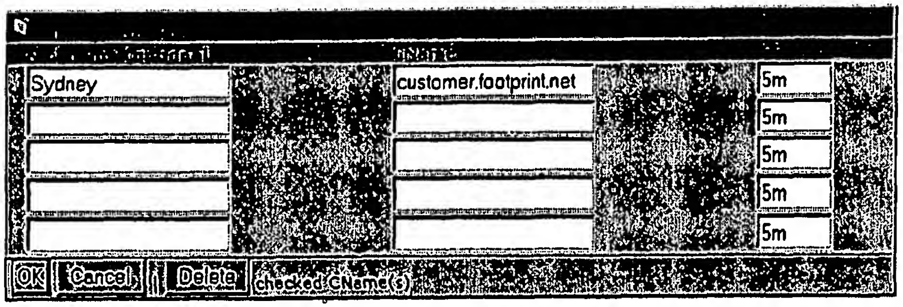
checked static server(s)

Fig. 9(a)



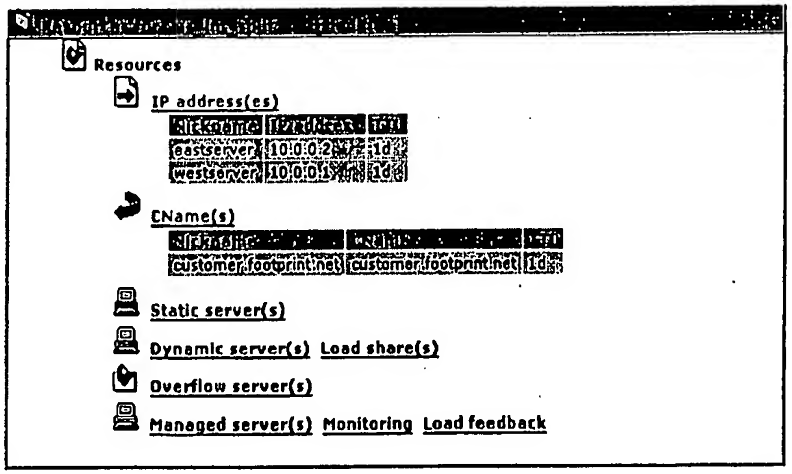
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
London	10.0.0.3	5m	http://server	paul	--------
		5m	http://server		
		5m	http://server		
		5m	http://server		
		5m	http://server		

Fig. 9(b)



[illegible]	CName	
Sydney	customer.footprint.net	5m
		5m
		5m
		5m
		5m

Fig. 9(c)



Resources

IP address(es)

Nickname	IP address	TTL
eastserver	10.0.0.2	1d
westserver	10.0.0.1	1d

CName(s)

Nickname	[illegible]	TTL
customer.footprint.net	customer.footprint.net	1d

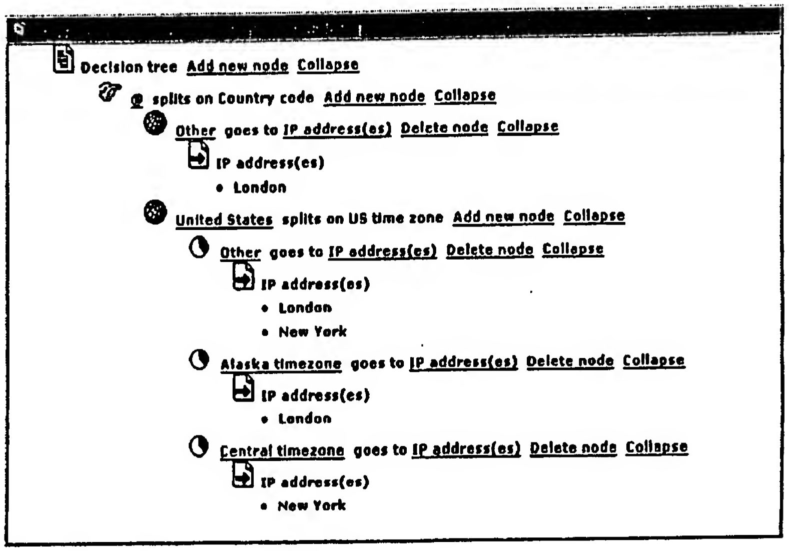
Static server(s)

Dynamic server(s) Load share(s)

Overflow server(s)

Managed server(s) Monitoring Load feedback

Fig. 10(a)



Decision tree Add new node Collapse

@ splits on Country code Add new node Collapse

Other goes to IP address(es) Delete node Collapse

IP address(es)

- London

United States splits on US time zone Add new node Collapse

Other goes to IP address(es) Delete node Collapse

IP address(es)

- London
- New York

Alaska timezone goes to IP address(es) Delete node Collapse

IP address(es)

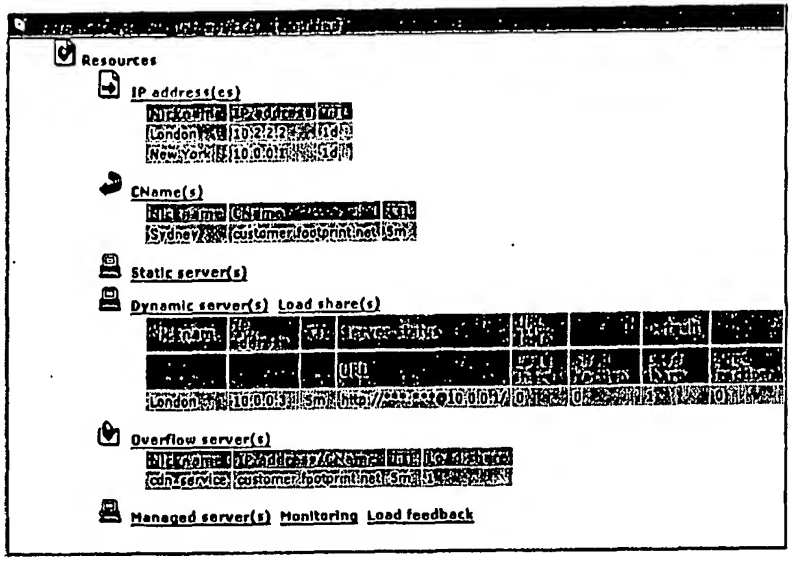
- London

Central timezone goes to IP address(es) Delete node Collapse

IP address(es)

- New York

Fig. 10(b)



Resources

IP address(es)

Nickname	IP address	TTL
London	10.2.2.2	1d
New York	10.0.0.1	1d

CName(s)

Nickname	CName	TTL
Sydney	customer.footprint.net	5m

Static server(s)

Dynamic server(s) Load share(s)

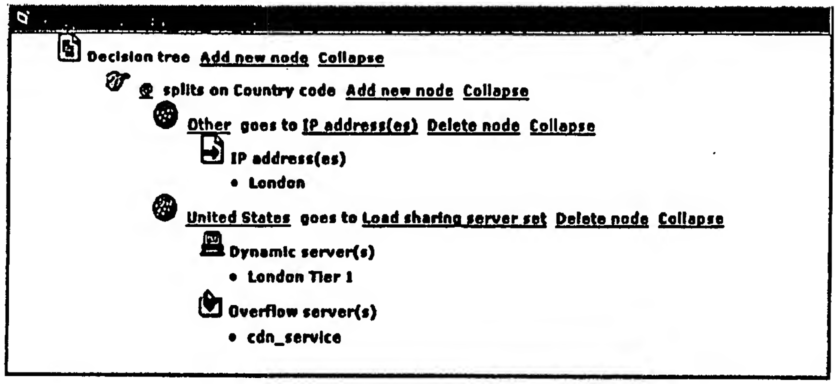
Nickname	IP address	TTL	Server status	[illegible]	[illegible]	[illegible]	[illegible]
			URL	[illegible]	[illegible]	[illegible]	[illegible]
London	10.0.0.3	5m	http://[illegible]@10.0.0.1/	0	0	1	0

Overflow server(s)

Nickname	IP address / CName	TTL	Load share
cdn_service	customer.footprint.net	5m	1

Managed server(s) Monitoring Load feedback

Fig. 10(c)



Decision tree Add new node Collapse

splits on Country code Add new node Collapse

Other goes to IP address(es) Delete node Collapse

IP address(es)

- London

United States goes to Load sharing server set Delete node Collapse

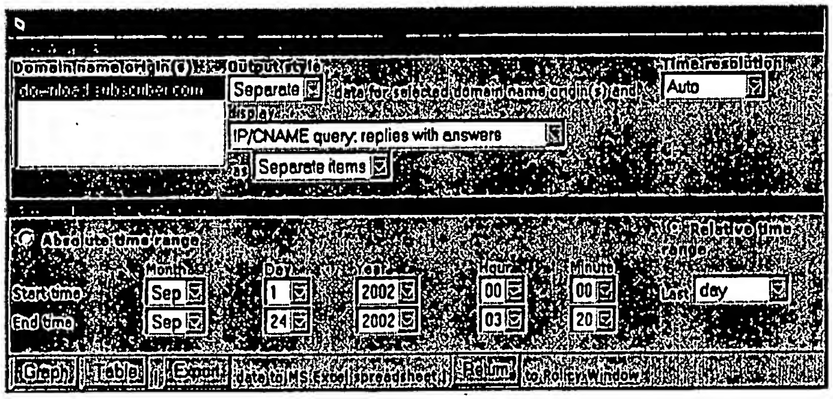
Dynamic server(s)

- London Tier 1

Overflow server(s)

- cdn_service

Fig. 10(d)



Domain name origin(s)

download.subscriber.com

Output style

Separate data for selected domain name origin(s) and display

IP/CNAME query: replies with answers

as Separate items

Time resolution

Auto

○ Absolute time range

	Month	Day	Year	Hour	Minute
Start time	Sep	1	2002	00	00
End time	Sep	24	2002	03	20

○ Relative time range

Last day

Fig. 11(a)

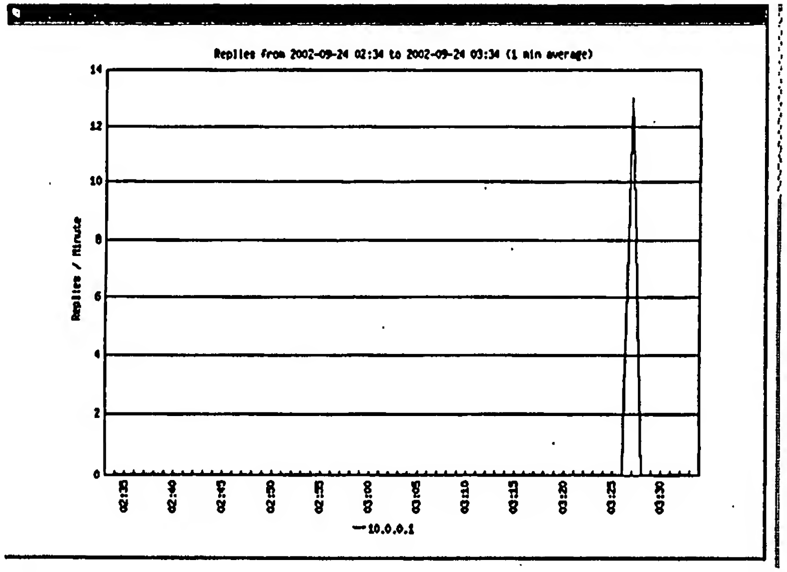
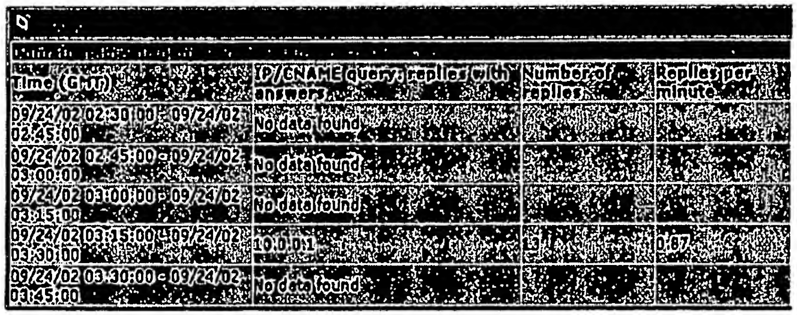

Replies from 2002-09-24 02:34 to 2002-09-24 03:34 (1 min average)
Replies / Minute
14
12
10
8
6
4
2
0
02:35
02:40
02:45
02:50
02:55
03:00
03:05
03:10
03:15
03:20
03:25
03:30
—10.0.0.1

Fig. 11(b)



Time (GMT)	IP/CNAME query: replies with answers	Number of replies	Replies per minute
09/24/02 02:30:00 - 09/24/02 02:45:00	No data found		
09/24/02 02:45:00 - 09/24/02 03:00:00	No data found		
09/24/02 03:00:00 - 09/24/02 03:15:00	No data found		
09/24/02 03:15:00 - 09/24/02 03:30:00	10.0.0.1	13	0.87
09/24/02 03:30:00 - 09/24/02 03:45:00	No data found		

Fig. 11(c)

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(74) Agents: **SIRITZKY, Brian** et al.; Heller, Ehrman, White & McAuliffe LLP, 1666 K street, N.W., Suite 300, Washington, D.C. 20006-1228 (US).

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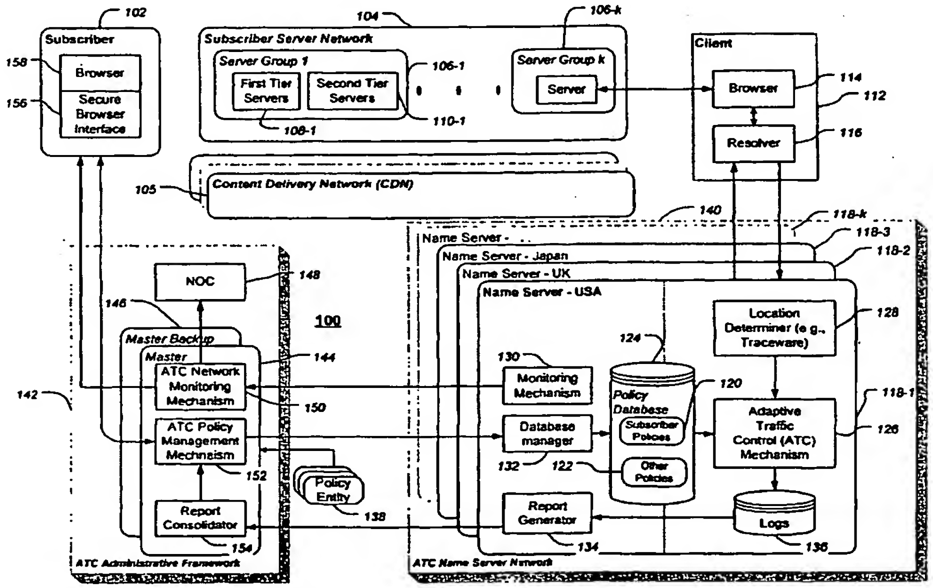
[Continued on next page]

(54) Title: SYSTEM AND METHOD FOR POLICY DEPENDENT NAME TO ADDRESS RESOLUTIOIN.



(57) Abstract: A framework for delivery of Internet content includes a subscriber server network; and at least one domain name server constructed and adapted to provide policy-based domain name service, wherein, in response to a request to resolve a hostname, the domain name server resolves the hostname to at least one address corresponding a server in the subscriber server network based on at least one policy consideration. Some examples for possible policies are geographic policies , load share policies or overflow policies.

European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

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Interna l Application No
PCT/US 02/30921

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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 817 444 A (SUN MICROSYSTEMS INC) 7 January 1998 (1998-01-07) abstract figure 3 column 1, line 1 - column 3, line 21 column 5, line 6 - column 7, line 58 -----	1-14, 16-19, 29-32, 34,35, 42-45, 48-51, 63-66, 68,69
X	US 6 282 574 B1 (VOIT ERIC A) 28 August 2001 (2001-08-28) column 4, line 40 - line 50 ----- -/--	1

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☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

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Date of mailing of the international search report

28. 01. 04

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INTERNATIONAL SEARCH REPORT

Interna l Application No
PCT/US 02/30921

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 00/52594 A (JOFFE RODNEY L ;LACHMAN RONALD (US); ULTRADNS INC (US); HOTZ MICHA) 8 September 2000 (2000-09-08) page 4, line 1 - page 7, line 6 page 16, line 17 - line 25 -----	1